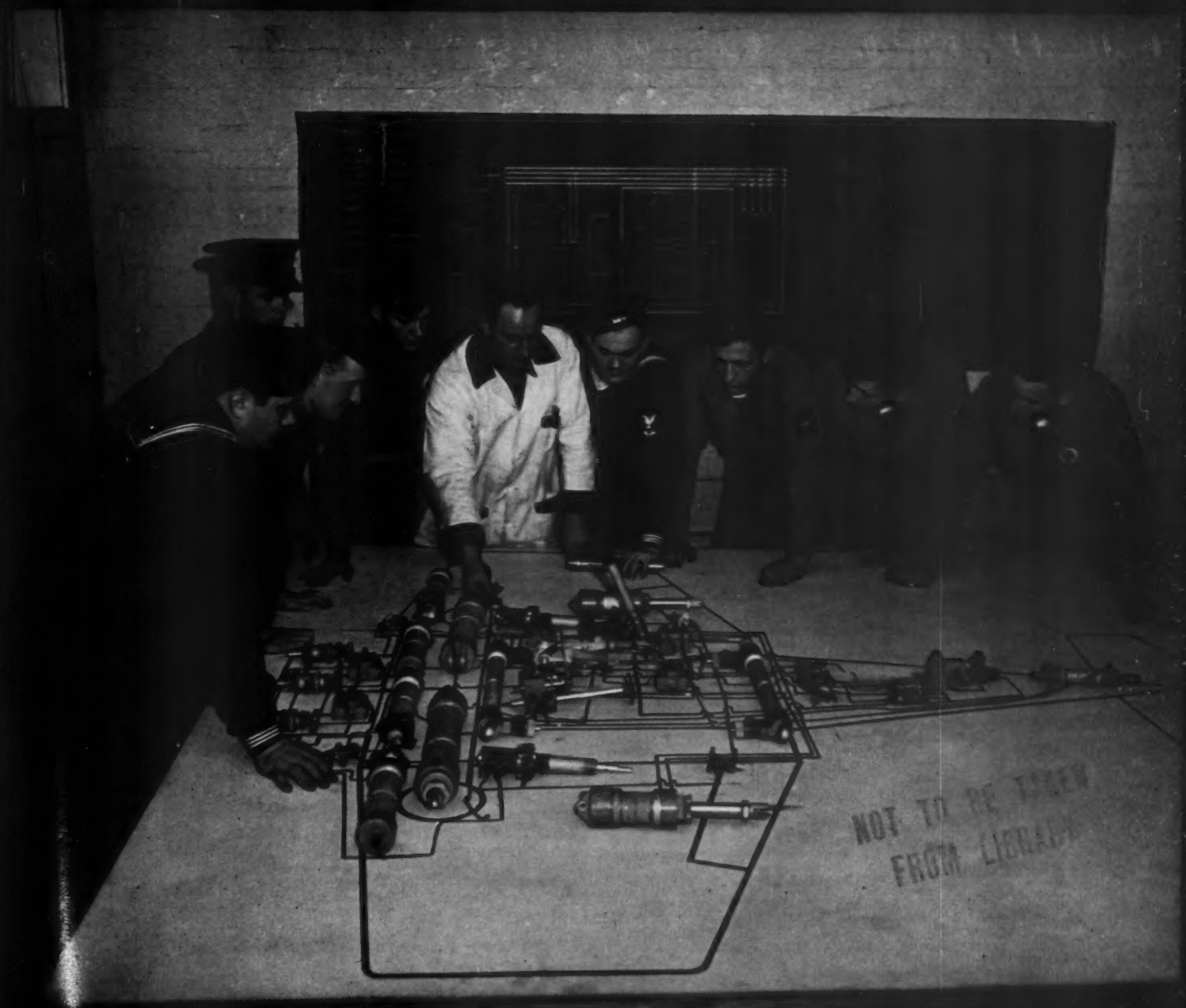
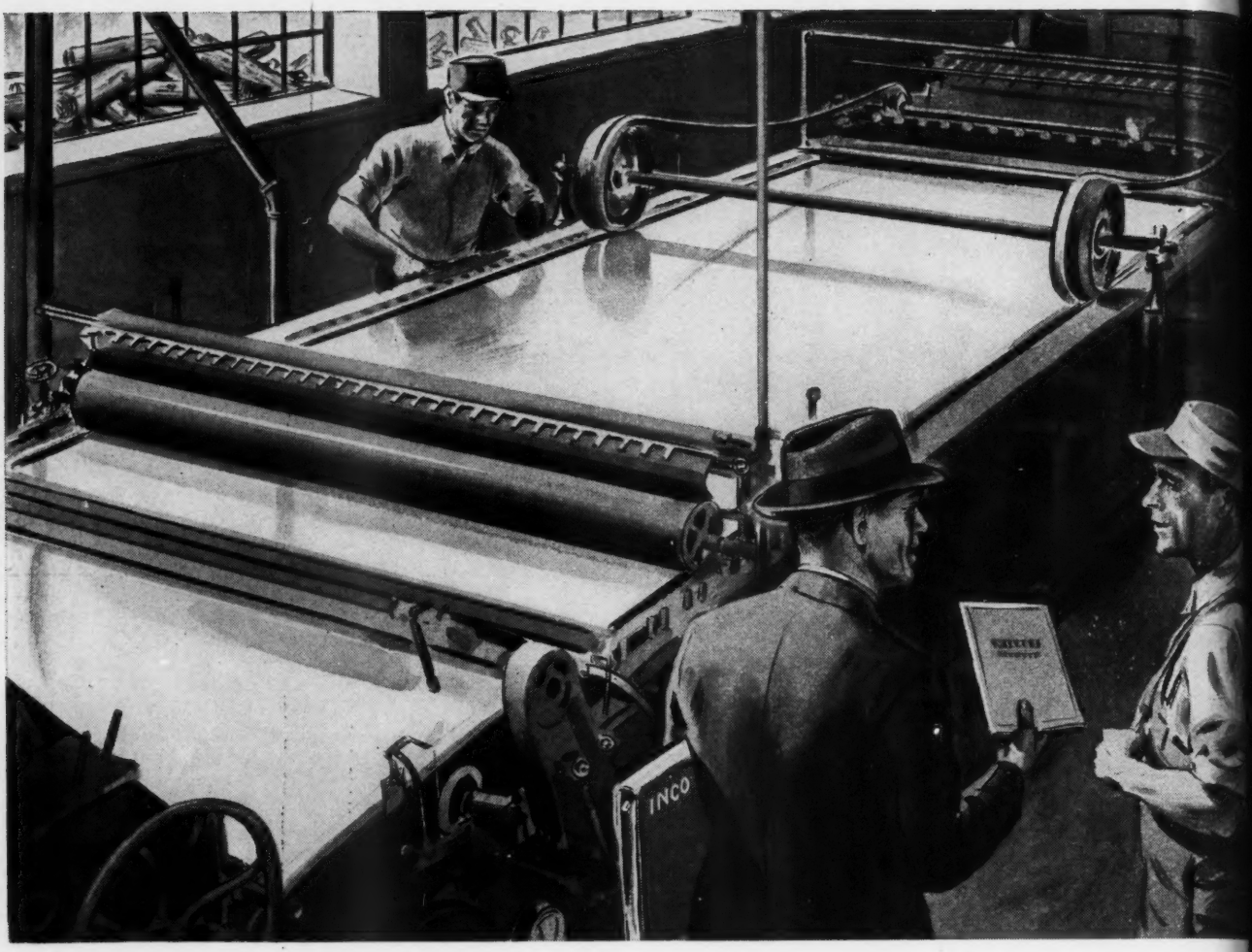
PRODUCT ENGINEERING

FEBRUARY, 1944





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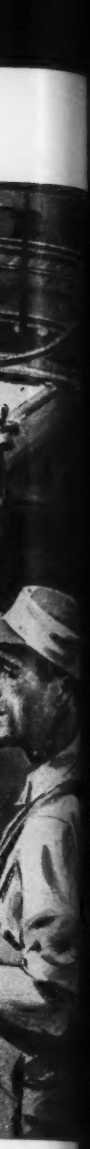

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PRODUCT ENGINEERING

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✦

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✦

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IN THIS ISSUE

Cover Picture

An Electrol, Inc., engineer instructs Navy and Marine technicians in the functions and servicing of hydraulic controls for military aircraft. Units are laid out in the same relative positions as on the actual plane.

Melamine Development

As a raw material melamine is over 100 years old. Only in recent years, however, was it combined with formaldehyde to form a resin that could be used as a thermosetting plastic. Now, applications of filled melamine-formaldehyde compounds in war equipment are being continually developed because of several special properties that these compounds possess. See page 99 for a resume of the high points of this new plastic material. The article is based on data from Plastics Div., American Cyanamid Company; Plastics Div., Monsanto Chemical Company; Plastics Dept., General Electric Company;

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Special Section: Hydraulic Controls

New developments in hydraulic units stimulated by wartime applications in planes, tanks and ships, have done much to encourage still further adoption to all types of industrial machinery. On page 105 a 16-page special section describes basic functions and characteristics of hydraulic pumps, valves and motors, emphasizing application possibilities.

Basic Electronic Circuits

Electronic circuits, regardless of how complicated they appear when first studied, consist of basic circuits designed to perform a particular function. Circuits for some of the basic functions were illustrated and described in the January issue of PRODUCT ENGINEERING. On page 92 appears drawings and explanations of circuits for other basic functions. This series on basic circuits follows a special section appearing in the October issue devoted to basic functional electronic circuits and their industrial applications.

Steel Mesh Sheet

Steel sheet applications are often limited by lack of stiffness or rigidity in thin sheets. If these qualities are obtained by increasing thickness, the strength and weight requirements are greatly exceeded. Engineers of Consolidated Vultee Aircraft Corporation and Republic Steel Corporation succeeded in developing a composite sheet of diamond-mesh screen spot-welded to thin sheet steel to obtain the desired stiffness in thin, lightweight steel sheet. This development and applications are described in an article beginning on page 73. Use of composite sheet in side panels of aircraft and suggested post-war applications are discussed.

Special Design Features Of Aircraft Motors

As a sequel to "Design Specifications for Aircraft Motors" which appeared in the January number, William H. Fromm of The Dumore Company, see page 102, describes some special design features that have been incorporated in fractional horsepower motors to meet the demands imposed by braking requirements, travel limits, speed governing and automatic control.

Simplified Method for Designing Beam Sections—II

Summarizing and concluding the analysis and derivation of the simple method, presented in Part I, for arriving at satisfactory proportions of sections of beams as used in machinery, William L. Govan, engineer, Dominion Engineering Works, Limited, see page 121, describes the procedure for checking and correcting preliminary calculations to obtain dimensions for the actual section.

Curved Flanges

Use of flanges on sheet-metal parts to stiffen them and to serve as means of attaching other parts presents design problems when flanges are curved because of the necessity to prevent wrinkling by shrinking convex flanges or stretching concave flanges. Frank M. Mallet presents his experience in aircraft work on page 124 with a systematic method of approaching design problems that takes all of the controlling factors into account.

Sub-Surface Fatigue Origins

Sub-surface fatigue origins in non-homogeneous materials subject to bending stresses offer every-day problems to design engineers. Frederick Franz, consulting engineer, has been asked to explain the subject on many occasions. On page 97 he presents a method for evaluating the safety of flexurally-stressed, heat-treated steel members.

Brazed Stampings

Stamped and formed sheet-steel parts joined by brazing methods that neither produce distortion nor create finishing difficulties are being used for many ordinance parts. Several of these parts and a few outstanding pre-war parts are illustrated in an article starting on page 76. These emphasize how careful design with thin sections enables lightweight sheet-metal construction to replace parts that required heavy sections.

Metal Spinnings

The scope of application of metal spinning was accurately defined recently by Milwaukee Metal Spinning Company. Brief illustrated examples on page 128 summarize the definitions. Of interest are the applications of segments and sectors of spinnings, which are brazed or welded into large formed sheet-metal parts to round contours.

Reproducing Templates

In this second installment of a series of articles covering all phases of template reproduction, variations of the method involving projection of the master layout onto a negative by means of a camera are discussed, beginning on page 130. This series is based on an exhaustive survey made by Thomas Miles, reproduction supervisor, Consolidated Vultee Aircraft Corporation, of template-reproduction facilities in various aircraft manufacturing plants.

Volute Spring Data

Two features of the volute make it interesting as a spring, and yet cause many headaches. The load-deflection diagram is not a straight line and working stresses are higher than those allowed in other coiled springs. H. O. Fuchs, engineer, product study department, General Motors Corporation, see Reference Book Sheets, pages 143 and 144, presents type curves and graphs of auxiliary functions which have been found to be effective in eliminating much of the tedium from volute spring design calculations.

WHAT'S COMING

Pneumatic Controls

Much attention is being focused today on the increased use of pneumatic systems for machine control and for operating mechanical devices that require quick, positive action of large forces. Engineers have also been studying the advantages of combining pneumatic controls with electrical or hydraulic systems. The March issue will include an article by E. E. Hewitt, assistant chief engineer of the Westinghouse Air Brake Company, discussing basic pneumatic systems and accessories, emphasizing the advantages and limitations of pneumatics for control of forces, proportional movements, and sequences. Typical circuits and schematic diagrams of basic units illustrate the article.

Special Sections

During the past six months, PRODUCT ENGINEERING has presented monthly special sections highlighting new developments in materials, parts and processes. These 16-page sections have dealt with plastics, electronics, steel castings, electric motors, finishes, and hydraulic controls. Beginning with the April number, this editorial service will appear every other month, starting with a comprehensive review of light metals. Other sections planned will cover electrical controls, plywoods, synthetic rubber, organic finishes, and fabricating processes.

PRODUCT ENGINEERING
FEBRUARY, 1944

Mesh sheet reinforcing ribs are spot-welded after mash dies fit their flanges snugly around the mesh.

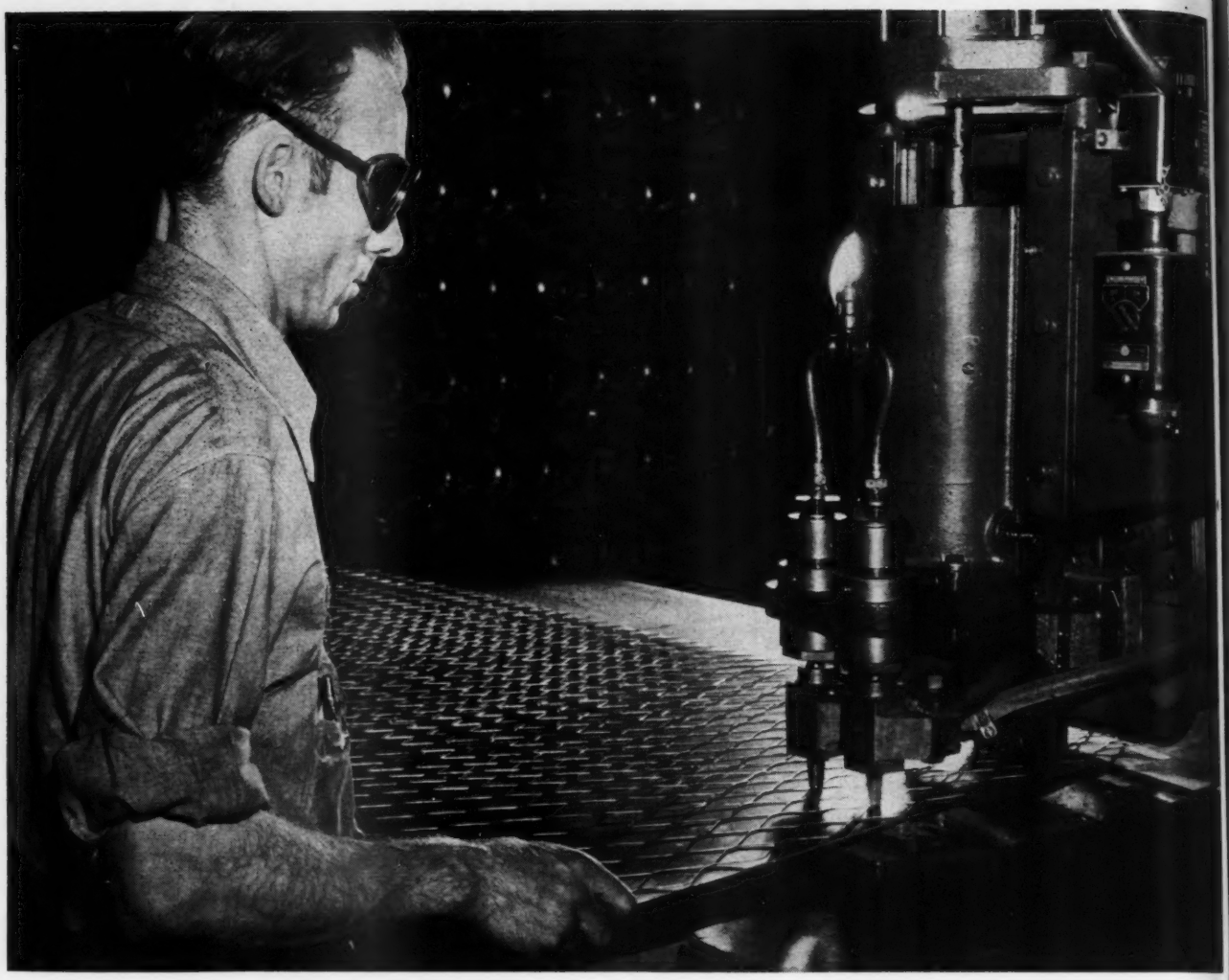
Steel-Backed Mesh Sheet For Light, Rigid Structures

Mesh sheet is satisfactory for airplane side sections and is under investigation for other applications requiring strong, stiff constructions. Fabrication of airplane panels is described and other possible uses of reinforced low-carbon steel are reviewed.

AIRPLANE side panels made of low-carbon steel similar to that used in automobile bodies, but reinforced with steel mesh spot-welded to one side, are now being used in place of aluminum sections in Vultee trainer planes. As it proves itself in service, this type of sheet is expected to gain increasing use, extending to all parts of airplanes, even combat types.

The side sections of trainers were selected for the first application of this new steel sheet because those panels are only moderately stressed. The sections, however, do have to withstand wind pressure generated by flying and are subjected to hard service and even abuse by maintenance crews and pilots. Pilots are liable to kick the side panels as they step into the cockpit. The panels of meshed sheet reinforcement consist of four prefabricated sheets with welded edging and reinforcing ribs. They are made with special fasteners for frequent removal by maintenance crews.

Mesh sheet, as produced by the Berger Manufacturing Division of Republic Steel Corporation, consists of 0.008 in. full-hard S.A.E. 1010 carbon steel sheet to which steel mesh has been spot-welded. This increases the effective thickness and the stiffness of the sheet with but slight increase in weight. Skin



Expanded mesh is spot-welded to steel sheet by a special pedestal welder with twin electrodes.

and mesh combine to form a composite section 0.063 in. thick.

The mesh is diamond-shaped, about 3¼ in. by 1¼ in. across corners, and is the standard type mesh used as lath for stucco work, as guard fencing around machinery, and as tray holders in refrigerators. It is formed of sheet steel which is slit and expanded flat in one operation so that the mesh cords have a rectangular cross-section of about 0.055 in. thick by 0.070 in. wide. The 0.070 in. width of the section is limited by clearance of the cutting knives and might otherwise be narrower.

Composite sheets weigh 0.53 lb. per sq. ft., of which the expanded mesh accounts for 0.2 lb. This compares with approximately 0.5 lb. per sq. ft. for the 0.035 in. thick aluminum panel that it replaces on the trainers. Since 0.008 in. sheet is just below commercial limits of the mills, its 0.33 lb. per sq. ft. comparing with 0.3440 to 0.5 lb. per sq. ft. for the lightest weight tinplate, it was necessary to overcome certain difficulties in maintaining required flatness and uniform sheet thickness.

Composite materials combining sheet with other lightweight materials, such as plywood and certain plastics, were tried by the Consolidated Vultee Aircraft Corporation but were found unsatisfactory because of differences in elasticities, coefficients of expansion and a number of other difficulties. In experimenting with various methods of reinforcing sheet steel, the Vultee research department tried perforated metal, wire mesh, and a number of different types of stringer reinforcements, and other forms of steel backing.

Expanded metal mesh was selected for several reasons: It is easily handled and applied; it is cold-worked in the process of expansion and becomes considerably stronger than unworked forms of the same steel; the composite sheet is easily shaped and fabricated; expanded metal mesh is readily available.

The most important engineering consideration in applying mesh sheet to aircraft is rust-proofing. This is accomplished on the completed panel by depositing a light "sacrificial" coat of zinc followed by Bonderizing to improve paint adherence. The zinc coating weighs only 0.06 oz. per sq. ft. as compared with average commercial practice of 1 oz. per sq. ft. of surface. The mesh side of the sheet is sprayed with a clear lacquer-like plastic cement, which fastens strands of the mesh between welds to the sheet and provides a priming coat for paint after fabrication of the panel. The outside is sprayed with a zinc-chromate primer and followed by spray painting. Laboratory tests have shown that even deeply scratched samples treated this way withstand several hundred hours of salt spraying without rusting.

In the fabrication of airplane panels, the mesh sheet is shaped to approximately a 33 in. radius by passing it through standard rolls. All ribs, binding strips and reinforcing plates are spot-welded in place in locating fixtures.

The original design of panel section had a half-inch unreinforced edge which was turned over to form a binding strip. The sheet, therefore, had to have high ductility. As redesigned, a separate piece with the required ductility is used. This makes it possible to roll the skin sheet to a maximum yield strength approaching 100,000 lb. per sq. in. The

Galvanized and Bonderized panels are spray painted with primer, then given a finish coat as required by AAF specifications.

Three types of fuselage side panels for Consolidated Vultee basic trainers.

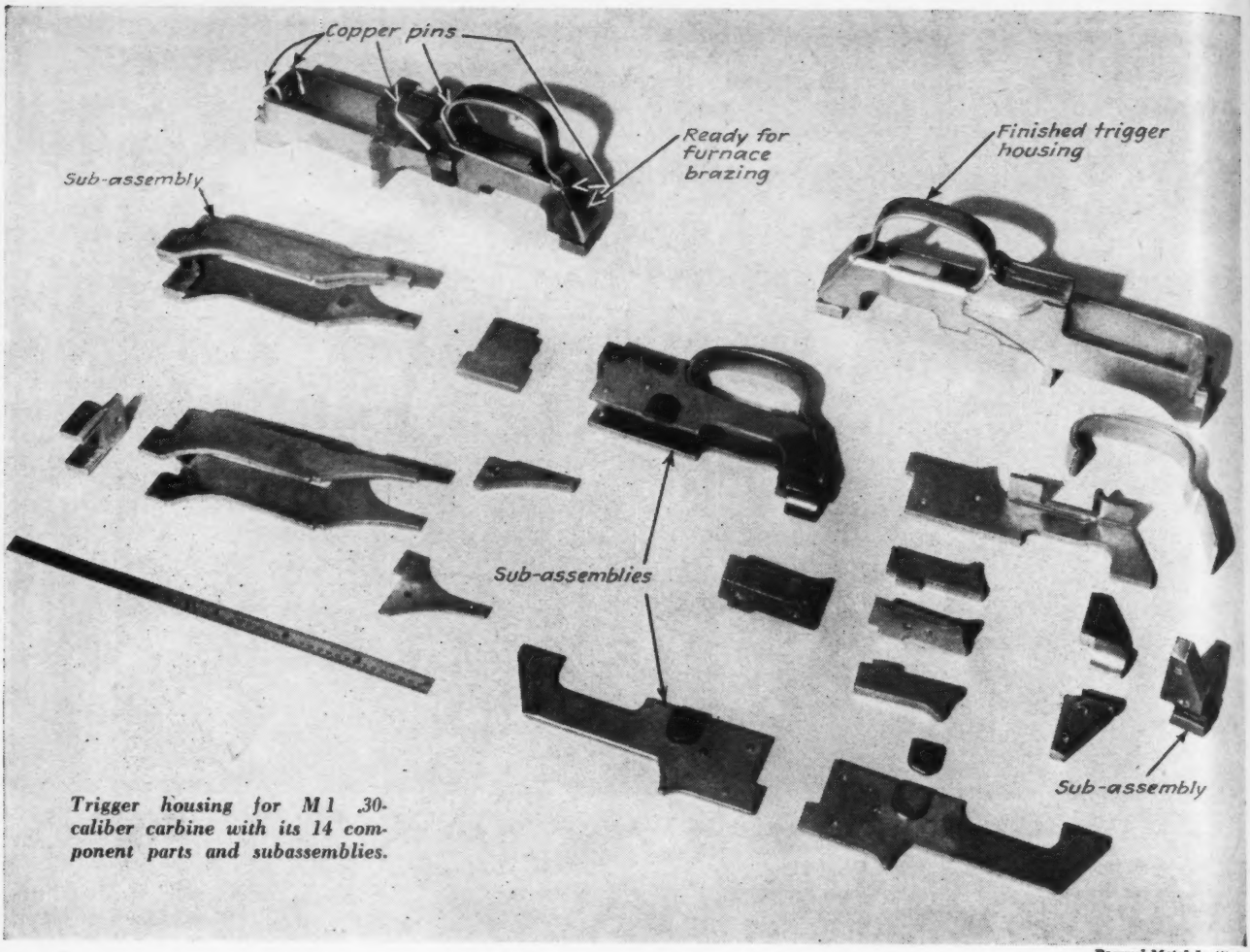
binding edge strip has only 75,000 lb. per sq. in. tensile strength, but 10 percent elongation. The maximum width of mesh sheet now obtainable is 30 inches.

Steel has a natural high fatigue limit and thus is suitable for applications where a material must have high resistance to vibration under stress. "Oil-canning" is reduced measurably, particularly noticeable because of the silencing effect of the mesh. Republic's metallurgical staff is of the opinion that these mesh-sheet panels will be as satisfactory as aluminum in other respects besides meeting the strength-weight ratios.

The new mesh sheet is expected to be useful anywhere on an airplane where large radii curves are permissible: In cowlings and other fuselage sections and the highly-stressed wings. Mesh sheet can be bent to form corners but attempts to form the composite sheet in surfaces of comparatively small radii result in stretched or distorted mesh. Thus, if design calls for fabrication of a rectangular box section with flat sides and sharp corners, the mesh sheet can be so formed, but not if rounded corners are used.

While little thought has been given to possible peacetime applications of this type of material, some investigations are being made. A truck manufacturer is considering its possibilities in cabs and truck body tops where its use would reduce truck weight by 300 lb. Lockers might be made lighter in weight without producing "tinniness" or without the necessity for built-up sections. The same might apply to all kinds of cabinets, steel desks, furniture and other items. For such uses it is anticipated that mesh sheet will be available in strips up to 30 in. wide and as long as may be practical for rail transportation.

Mesh sheet can be produced with the mesh applied in any desired pattern. Other forms of composite sheet have also been developed. These consist of two thin sheets, one of which is plain and the other stamped in various grid and punched forms before being spot-welded together. Rust-proofing of this type of composite sheet will probably be done on the inside before the two sheets are joined. Another post-war possibility is composite sheet of corrosion-resistant sheet metals.



Trigger housing for M1 .30-caliber carbine with its 14 component parts and subassemblies.

Pressed Metal Institute

Stampings Joined by Brazing Make Low-Cost Sturdy Parts

Several outstanding illustrations of stamped and brazed sheet-steel parts for both war and peacetime show the possibilities of combining these fabricating methods for producing sturdy, lightweight and economical designs.

FABRICATION of stamped and formed sheet-metal parts joined by brazing has been greatly stimulated by developments in brazing that produce clean, smooth, high-strength joints requiring no secondary operations before finishing. Much of the success of this type of fabrication can also be attributed to the ability of producing close tolerances on pressed-metal parts so that close fits are obtained readily for joints to be brazed. Advantages include sturdiness in lightweight parts, low cost, material conservation and savings in time.

Sheet-steel stamping and forming engineers have had unlimited opportunity to design and redesign thousands of wartime parts. They have utilized facilities made idle by stoppage of peacetime production, relieved congestion in foundries, forge shops, and machine shops, and have conserved materials and manpower. Pressed Metal Institute, a new organization of firms interested in sheet-metal fabrication, is stimulating development and application of stampings, pressed-metal parts and assemblies of these parts.

Common brazing materials are silver brazing alloys and pure copper, both of which are easy to apply. All of the examples to be described use one or the other of these materials. At their melting points of about 1,175 and 1,980 deg. F. respectively, or slightly above, they

flow readily, wetting steel surfaces and filling joints by capillary attraction. Copper is considerably cheaper than silver alloy and requires no flux. Copper-brazed joints of highest quality are produced when a uniform heat is applied with the part surrounded by an atmosphere that prevents surface oxidation, as in a furnace. Copper can be applied in the form of shaped wire, foil, powder paste, or even small slugs. It can also be sprayed on joints by metal spray guns.

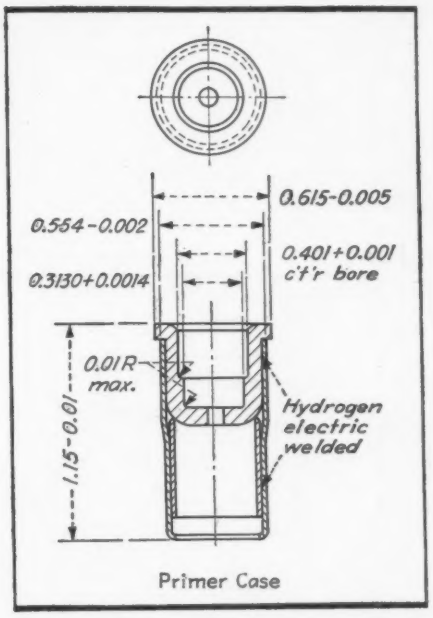
Strength of brazed joints is sometimes greater than that of the parent metal, particularly when mating members have been carefully fitted. In production, copper-brazed joints usually have a strength intermediate between that of copper and steel, and considerably greater than copper. A number of factors are involved in obtaining high strength, particularly the snugness of fit in the joint and proper timing of heating.

Tensile strengths as high as 130,000 lb. per sq. in. are reported with Handy and Harmon's Easy-Flo silver-brazing alloy under ideal conditions of joint thickness but usual values range between 50,000 and 100,000 lb. per sq. in. It usually takes less time to heat silver brazing alloy above its melting point except in a furnace where temperature gradient is high and there is not as great necessity for special atmospheres to prevent oxidation of the steel. Heat can be applied by several methods including torch, furnace, dip brazing, and high-frequency induction. Wire or strip are the usual forms of the alloy. Use of spot and projection welds in assembly often simplify furnace brazing by eliminating holding fixtures.

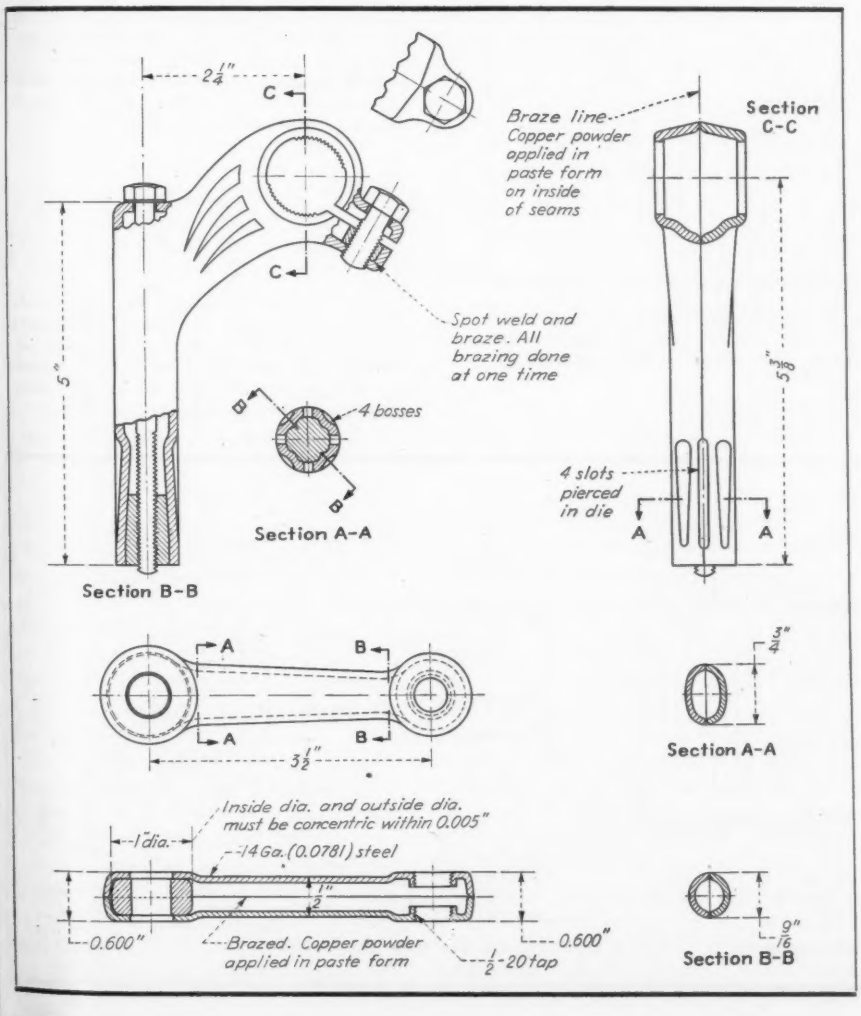
Newest development in design and application of sheet-metal stampings is what might be called laminated or ply-metal parts. In this type of construction simple stampings are assembled by projection welds and bonded into a laminated structure by molten copper, silver solder, or other brazing alloys. Matching of right and left formed stampings to produce hollow parts joined edge to edge by copper brazing is another type of design that has resulted from the simplicity and cleanliness of brazing and the accuracy in production of stamped parts.

One part that is made by laminating or stacking and assembling stamped members is a trigger housing developed by Murray Ohio Manufacturing Company and Conversion Engineering Section of Cleveland Ordnance for the new M 1 .30-caliber carbine. Fourteen simple stampings are combined in this housing, which nearly duplicates and is interchangeable with a trigger housing machined from a forging. Cost of the housing was reduced to half the peacetime cost of a machined forging and about one-fourth as much as they would have cost under present wartime conditions.

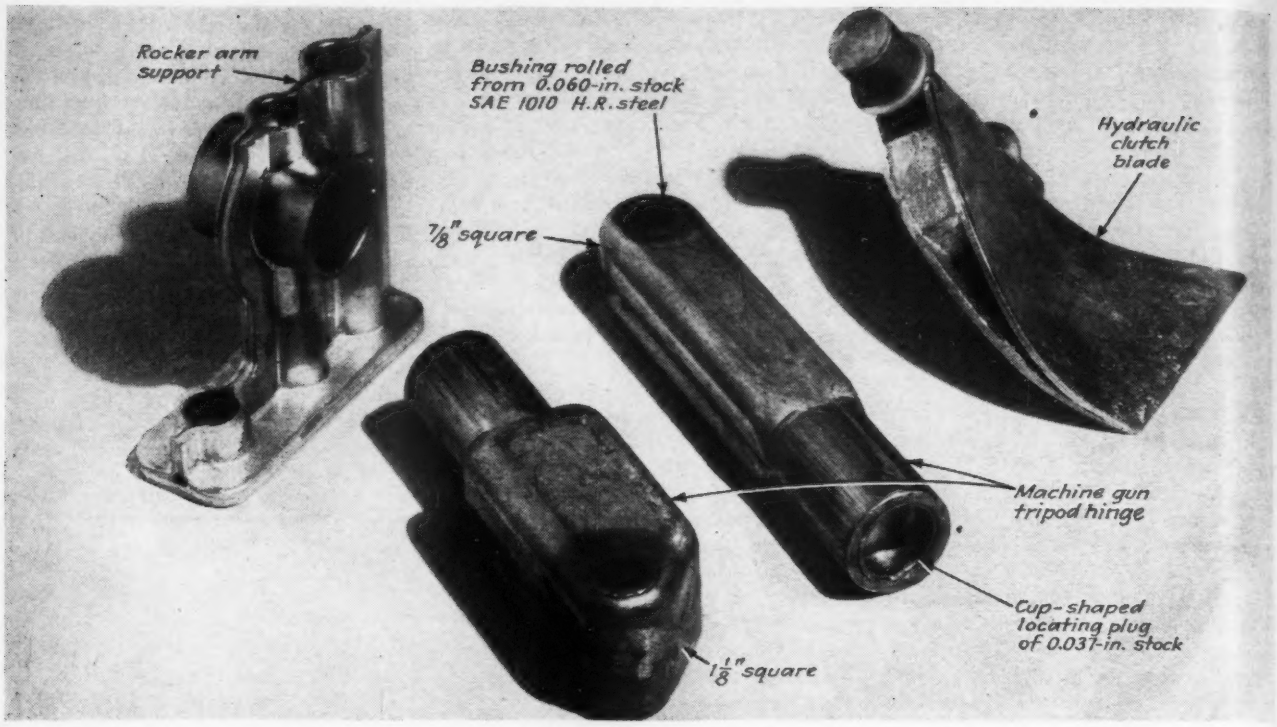
Although all parts of this trigger housing are of plain low-carbon steel,



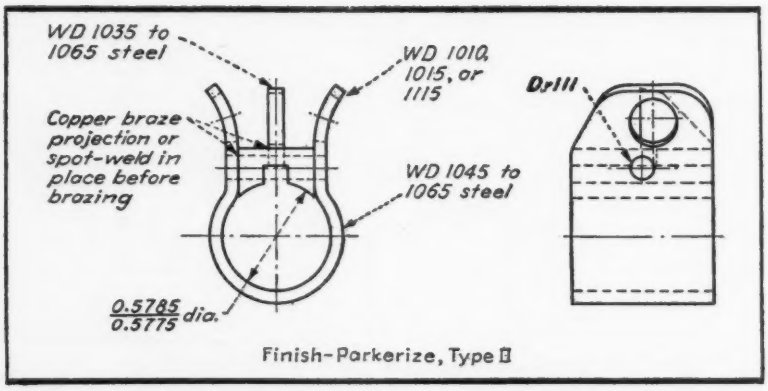
Primer case, made by Great Lakes Stamping Company, was made of brass bar on screw machines. All three of its tiny members are produced now by progressive stage dies. Allowance is made on the inner diameter after assembly for sizing with a 2-step reamer. Most tolerances range from 0.005 to 0.01 in. Allowable eccentricity between flange and outside cylindrical surface is held to 0.0034 in. Cost was greatly reduced and screw machines released for other work.


Braze line—Copper powder applied in paste form on inside of seams
Section C-C
Spot weld and braze. All brazing done at one time
4 bosses
Section A-A
4 slots pierced in die
Section B-B
Inside dia. and outside dia. must be concentric within 0.005"
1" dia.
14 Ga. (0.0781) steel
0.600"
Brazed. Copper powder applied in paste form
1/2-20 tap
Section A-A
Section B-B

Handle-bar support and pedal crank for a bicycle are pre-war examples of edge brazing stampings to form hollow parts. An important saving in surface preparation for chromium plating results because edges of mating parts are smooth before brazing and are not affected in passing through the brazing furnace. No grinding or polishing is necessary. All fittings have commercial tolerances. Great Lakes Stamping Company reports that these parts have higher strength than similar parts made as forgings or malleable castings before using stampings.

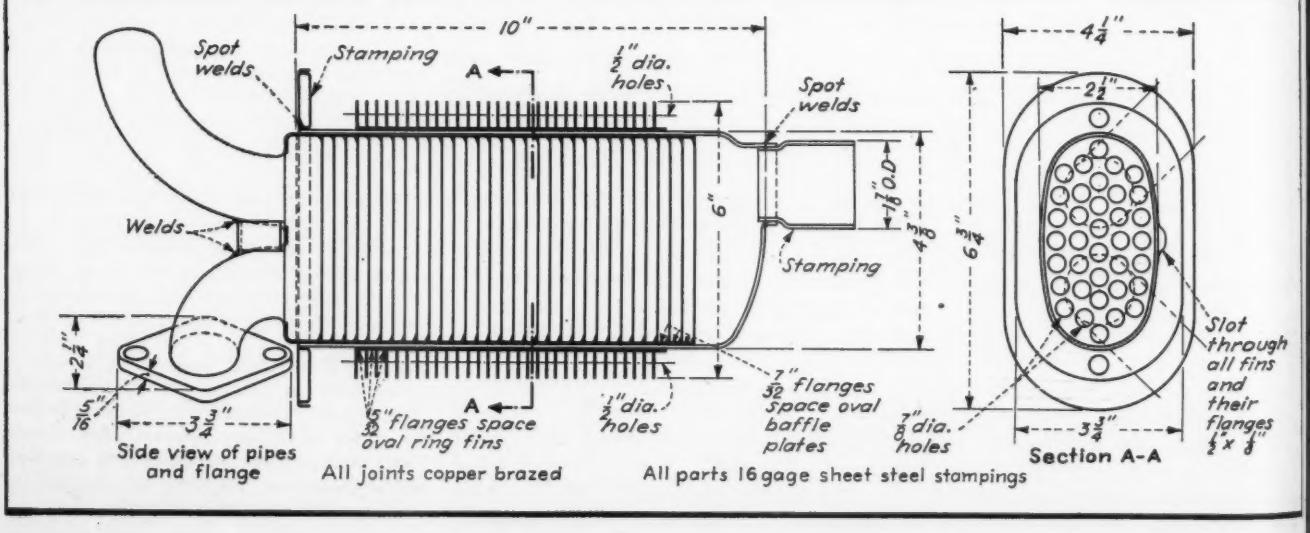

Rocker arm support
Bushing rolled from 0.060-in. stock SAE 1010 H.R. steel
7/8" square
Hydraulic clutch blade
Machine gun tripod hinge
Cup-shaped locating plug of 0.037-in. stock
1 1/8" square

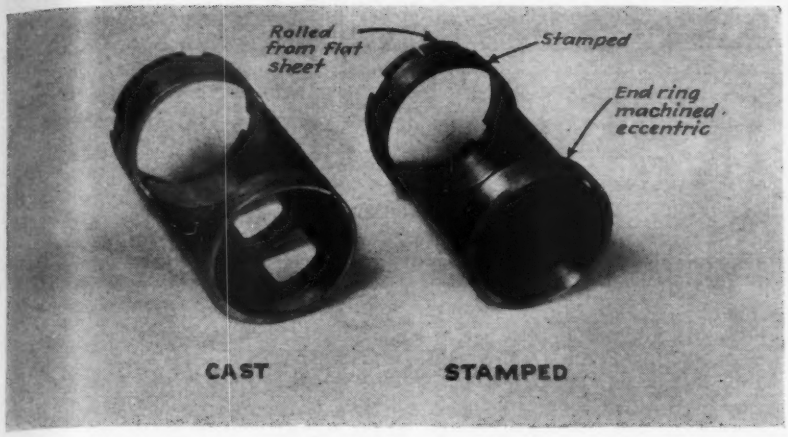
Tripod hinges for .30-caliber machine guns are good examples of hollow parts made by brazing together matched stamped members. They were formerly machined from solid forged bar and weighed three times as much. Hinges 1⅝ in. square are made for .50-caliber guns. Hinges, rocker arm support and hydraulic clutch blade are made by Toledo Stamping Company, and the latter two consist of four parts. All are shown as they come out of the furnace.


WD 1035 to 1065 steel
WD 1010, 1015, or 1115
Drill
Copper braze projection or spot-weld in place before brazing
WD 1045 to 1065 steel
0.5785 / 0.5775 dia.
Finish-Parkerize, Type II

Sight for .30-caliber carbine was formerly machined from bar stock and brazed on gun at a cost of 81 cents for the sight and 45 cents for the brazing operation. These costs have now been cut to 48.4 and 35 cents, respectively. Production rate is 10,000 per day.

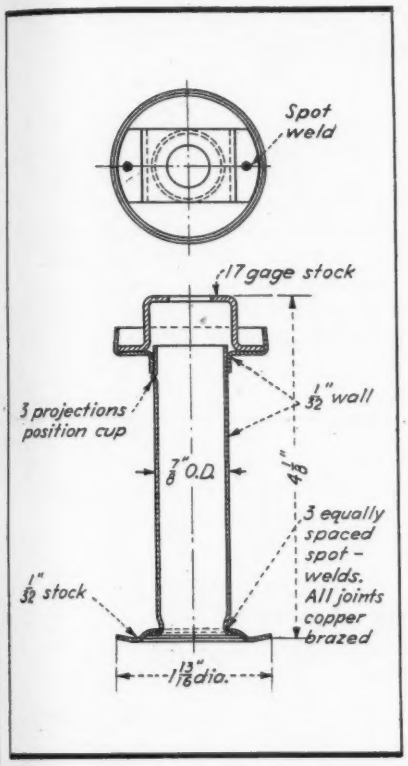
Center section through an automobile heater core made by Novi Equipment Company, which is one of the most interesting pre-war parts of brazed stamping design in the class of heat-transfer equipment for heating or cooling.



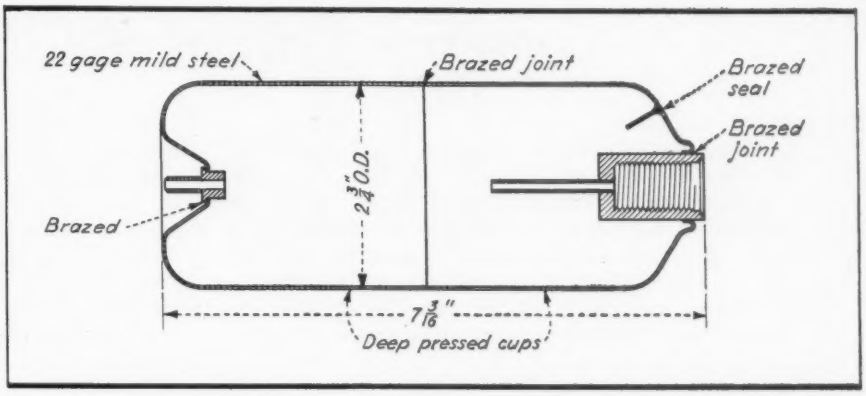


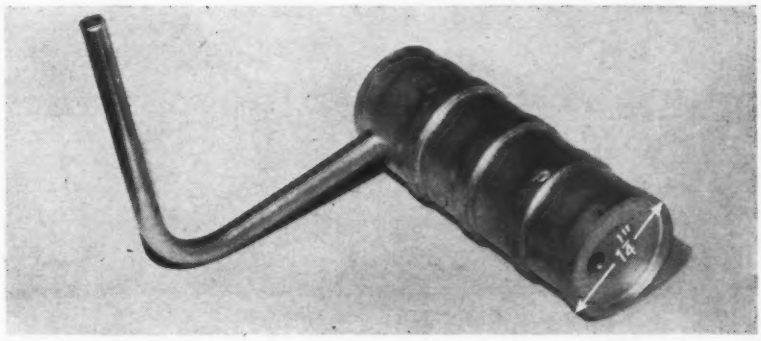
In redesigning this part of an automobile steering mechanism for stampings and brazed assembly Acklin Stamping Company made no saving in cost but did increase strength and conserve material. Rings need not be perfectly cylindrical on the outside because of machining. Spot-welds hold assembly for furnace brazing with copper.

Insecticide bombs for the Army are copper brazed by some producers, silver brazed by others to hold pressure.



Oil filter part designed by Harrison Radiator Company is copper brazed.





Four identical press-formed steel cups sealed together by copper brazing made a muffler for General Electric Company refrigerating equipment.

this new type of design might employ as many different materials as there are members in the assembly if necessary. Thickness of strip stock varies from 0.039 to 0.1495 in. In stamping out various members advantage can be taken of the metal grain in the strip, as in forging, to give each member its maximum strength.

The combination of several simple, stamped shapes is also significant in making possible the use of small presses and simpler machines in place of several types of machine tools and forging facilities. In making the trigger housing, milling operations were cut to one-sixth those required on a forged part, broaching was reduced to one-third, and profilers were eliminated entirely. Machining is now limited to precise finishing work, which is done in one-fourth of the time formerly required for machining, since 75 percent of the metal formerly removed from the forging is now removed in blanking out the parts of the housing.

Most dimensions are held within plus or minus 0.002 in. in order to get proper assemblies. This is accomplished in blanking, forming and coining, and shaving operations and during projection welding in assembly by means of positioning fixtures, most of which are simple in construction.

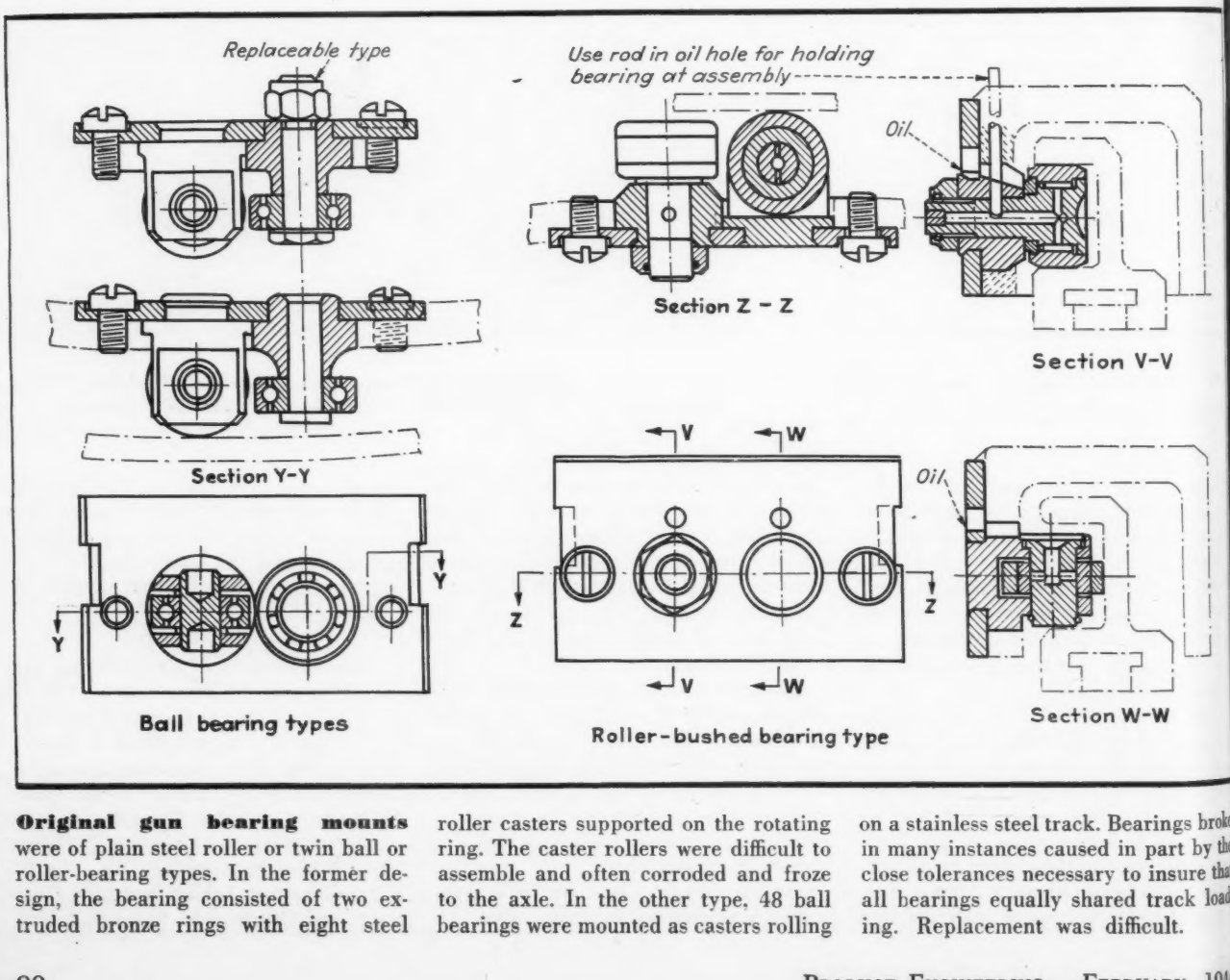
Copper brazing is done in a controlled-atmosphere furnace. Five U-shaped pins are laid on the housing. These pins contain slightly more than 0.1 oz. of copper but this may vary, depending upon the space requirements of the joints. Wire of 0.064 to 0.093 in. dia. is used.

Acknowledgement for providing material for this article is accorded to H. M. Webber, General Electric Company; E. C. Morse, Pressed Metal Institute; Murray Ohio Manufacturing Company; Toledo Stamping Company, Great Lakes Stamping Company, Prestole Division of Detroit Harvester Company, Salkover Metal Processing Company, Novi Equipment Company, Acklin Stamping Company, and Harrison Radiator Company.

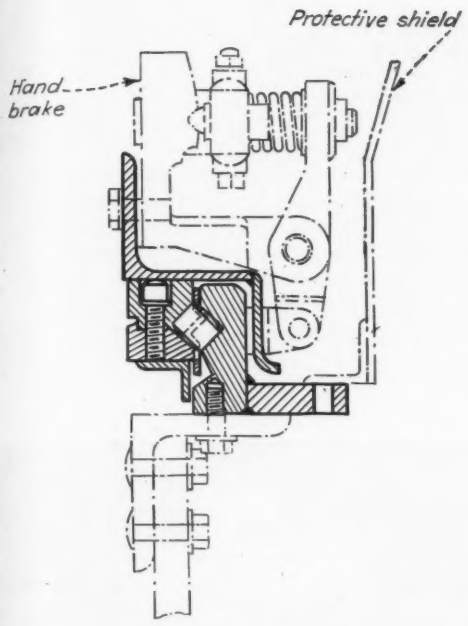
WARTIME DESIGNS

Simplified Turret Ring Design Conserves Critical Ball Bearings

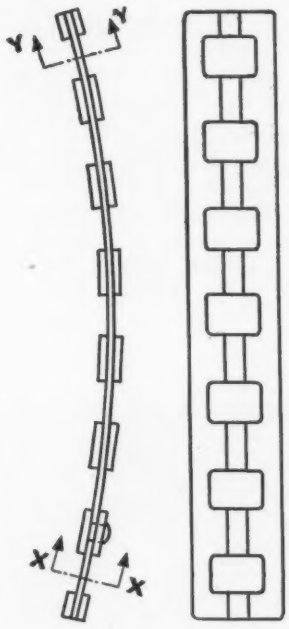
U. S. NAVAL ORDNANCE ENGINEERS in cooperation with General Bronze Corporation engineers have developed simplified ring bearing mounts for .30 and .50 twin caliber machine guns. Originally developed for PT boat and landing craft installations, these new designs can be easily adapted to other turret applications, such as on aircraft, tanks and anti-aircraft guns, to achieve substantial savings in critical materials, cost and production time. Races can be made of steel, extruded aluminum or magnesium sections; rollers can be steel, aluminum, magnesium or plastic to meet specified load and weight requirements. For some uses, hardened and ground raceways might be necessary, although sufficient load capacity could probably be obtained with proper selection of roller size and use of a maximum number of rollers in the assembly.



Original gun bearing mounts were of plain steel roller or twin ball or roller-bearing types. In the former design, the bearing consisted of two extruded bronze rings with eight steel roller casters supported on the rotating ring. The caster rollers were difficult to assemble and often corroded and froze to the axle. In the other type, 48 ball bearings were mounted as casters rolling on a stainless steel track. Bearings broke in many instances caused in part by the close tolerances necessary to insure that all bearings equally shared track loading. Replacement was difficult.



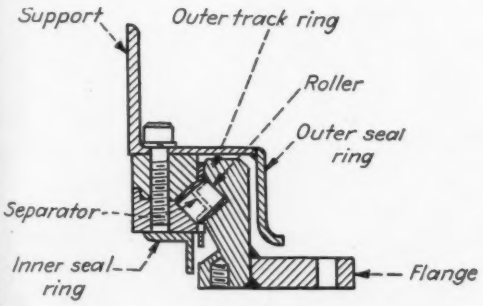
Typical section of track rings and rollers



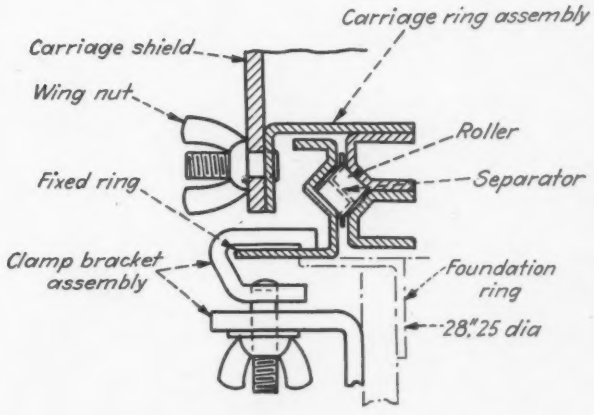
Sec. X-X

Sec. Y-Y

Roller separator



Bar stock design



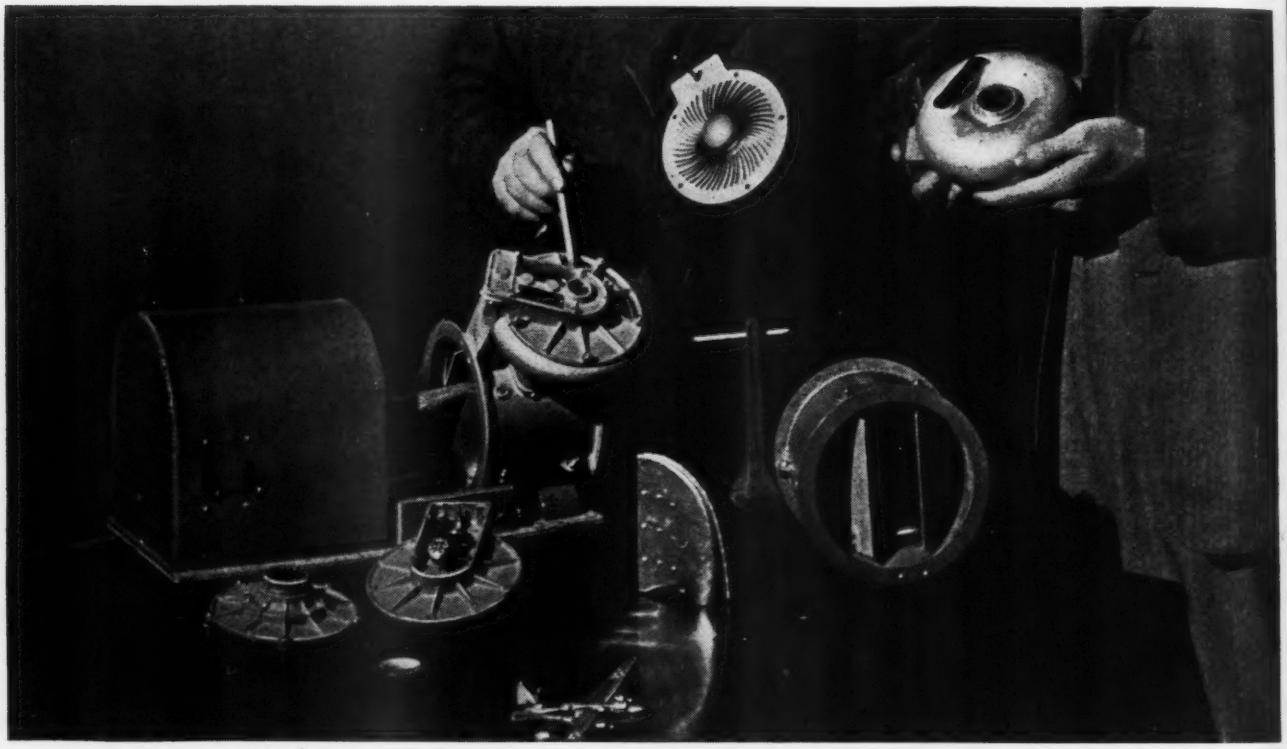
Rolled sheet design

Two new designs have been evolved. These greatly increase efficiency, eliminate strategic parts and cost considerably less to produce. In the design shown at left, 1045 bar stock steel is rolled into a circle of the required diameter, welded, stress-relieved and then machined into a V-cut for the roller race. No hardening or grinding is required. Separators are made from extruded brass in which holes are punched for the rollers. Separate assembly consists of 15 identical sections. Thus it is unnecessary to form a large-diameter, one-piece separator, which would be difficult to produce, fragile to handle and complicated to assemble. Rollers are cut from centerless ground bar stock. This design eliminates 48 ball bearings, a stainless steel ring, and much machining time. Cost was reduced about 59 percent per carriage. Another advantage of the design is that a single assembly takes load in all directions. Load capacity in up and down directions can be varied by proper angular placement of the rollers. In the PT boat bearing, every seventh roller takes upward thrust and remainder take downward loads. All rollers take radial thrusts.

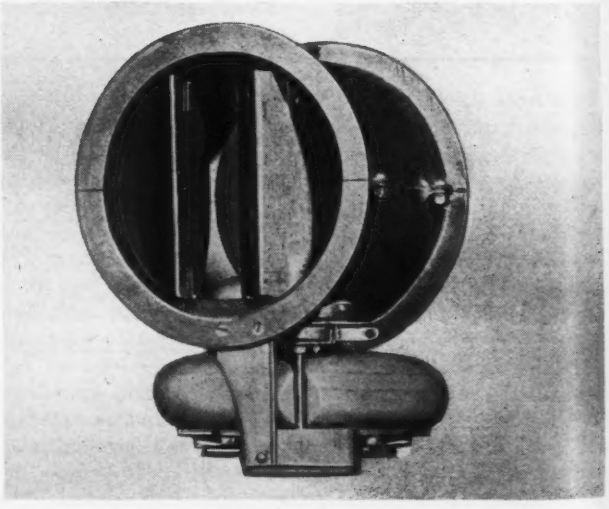
Rolled-up 1010 sheet annealed dead soft is used in the alternate design shown at right. The sheet is rolled to the desired sections in straight lengths and then formed on bending rolls to the required diameter. The ends are butt-welded and the surface of the V-raceway machine-finished. Separators are stamped from sheet stock and rollers cut from centerless ground bar stock. This design eliminates 36.5 lb. of bronze alone. It weighs only 25 lb. complete. Since raceways are 45 deg. surfaces, good drainage is provided. In addition to superior efficiency in operation, this design permits use of sheet steel instead of special bar sizes, with consequent drastic reduction in machining time.

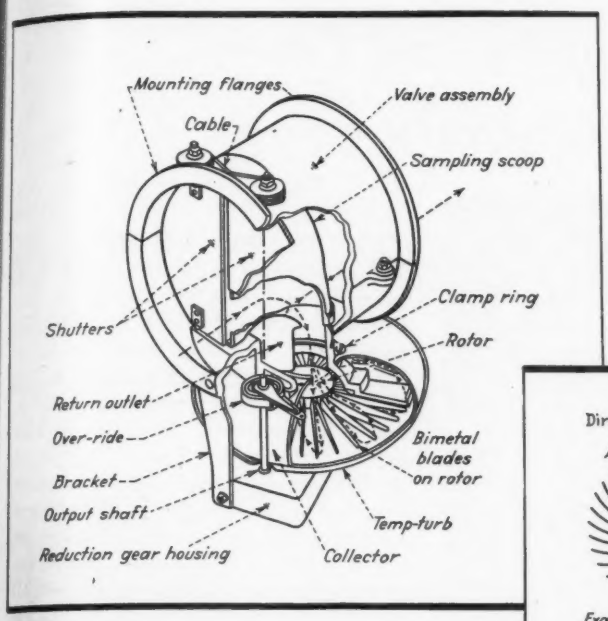
Air-operated Temperature Control Has Bimetallic Rotor Blades

BIMETALLIC thermosensitive elements similar to those used in automatic household irons have been adapted to a new temperature control device by J. R. Campbell, design engineer of the General Electric Company. The control, called the Temp-turb, is confined today to military aircraft, for governing air temperatures in cabin, gunner's compartment, de-icing ducts and related devices. It develops sufficient power to operate valves, shutters, gates, flaps and other mechanical devices which can control temperatures by regulating the velocity of the air flowing through a heater, or by adjusting the fuel intake at the heater, or by mixing hot and cold air. Device is light in weight, compact in size, has a minimum number of working parts.



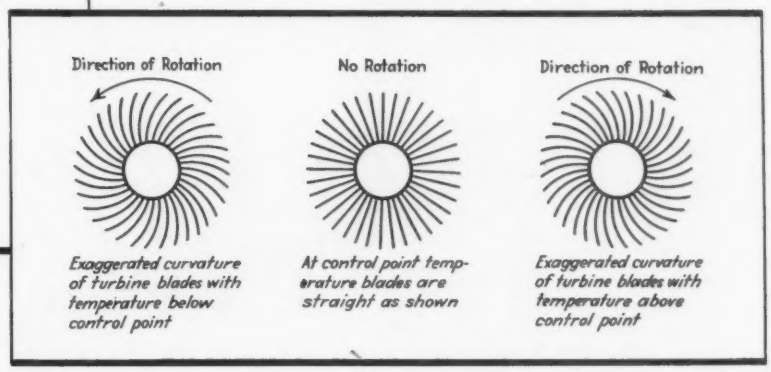
Operation. The Temp-turb operates as a simple impulse turbine. Since the bimetal turbine blades are not rigid, they reverse their direction of curvature as their temperature goes above or below a fixed control point. At the control point temperature of the unit the blades are straight and, therefore no torque or rotation is produced. When used in connection with a shutter-ring assembly, the device operates the shutters as the temperature goes above or below the control point. When temperature drops, shutters close sufficiently to restrict the flow of air through the heater so that air is discharged from the heater at the control-point temperature. If the temperature of the air is above the control point, the device operates in the opposite direction, shutters open, and air flow is increased. One advantage of the Temp-turb is that it provides a modulating, rather than an on-off adjustment. The greater the departure from the desired temperature, the more

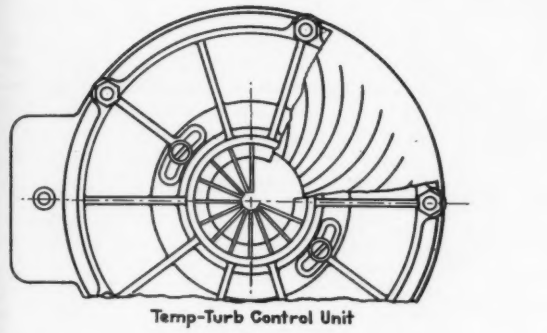




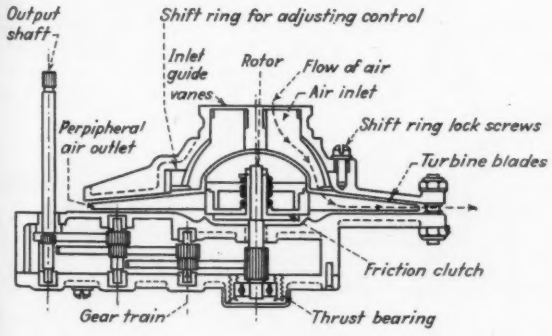
power developed by the rotor. Another advantage is that the device requires no external source of power other than that obtained from the velocity of air flowing through it.

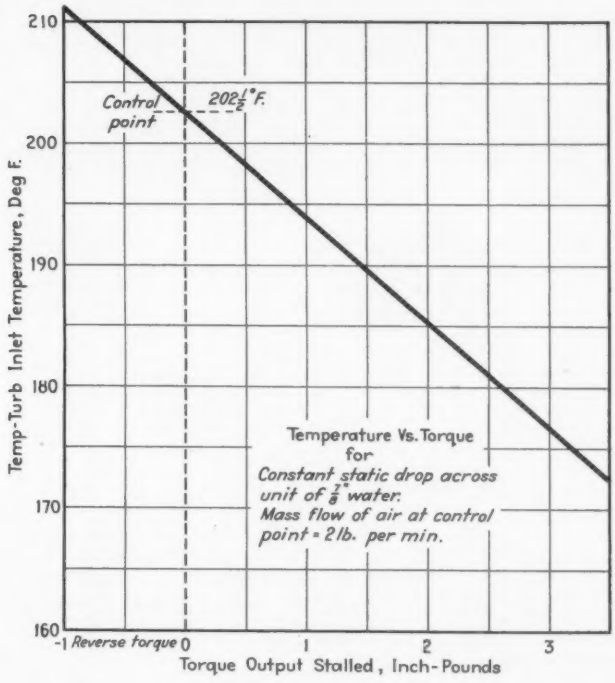
The device is designed to operate in any weather condition and in ambient temperatures ranging from —70 deg. F. to +250 deg. F. On the Havoc Bomber where it is used in conjunction with a heater and duct which supplies warm air for cabin heating and windshield defrosting, the control point is 200 deg. F. Tests show that the desired temperature is maintained within a range of ±5 deg. F. when the source of heat is close to the control assembly.


Direction of Rotation
No Rotation
Direction of Rotation
Exaggerated curvature of turbine blades with temperature below control point
At control point temperature blades are straight as shown
Exaggerated curvature of turbine blades with temperature above control point



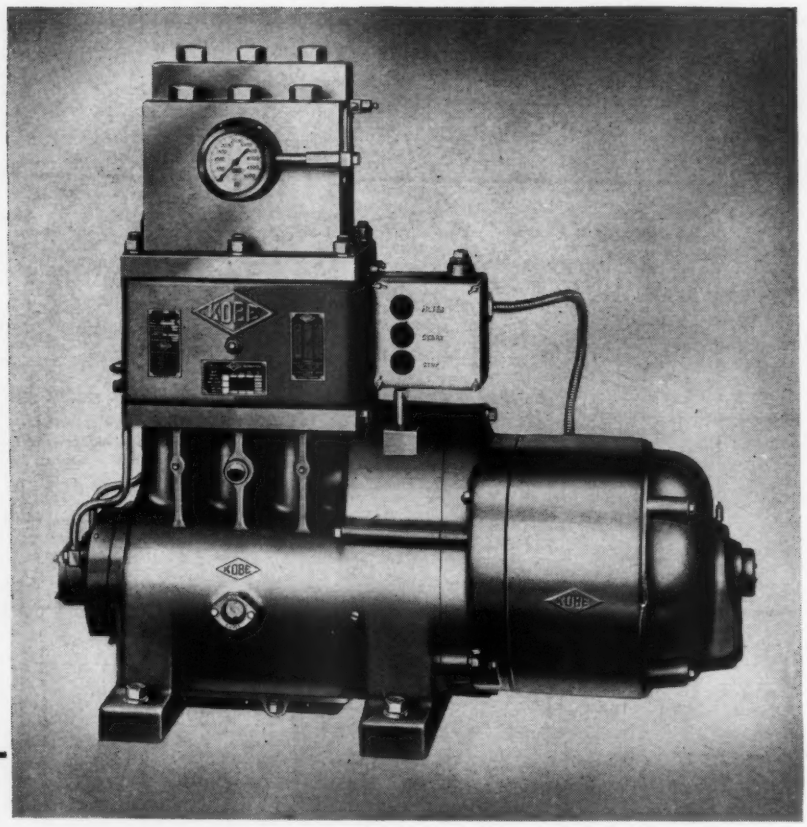
Temp-Turb Control Unit



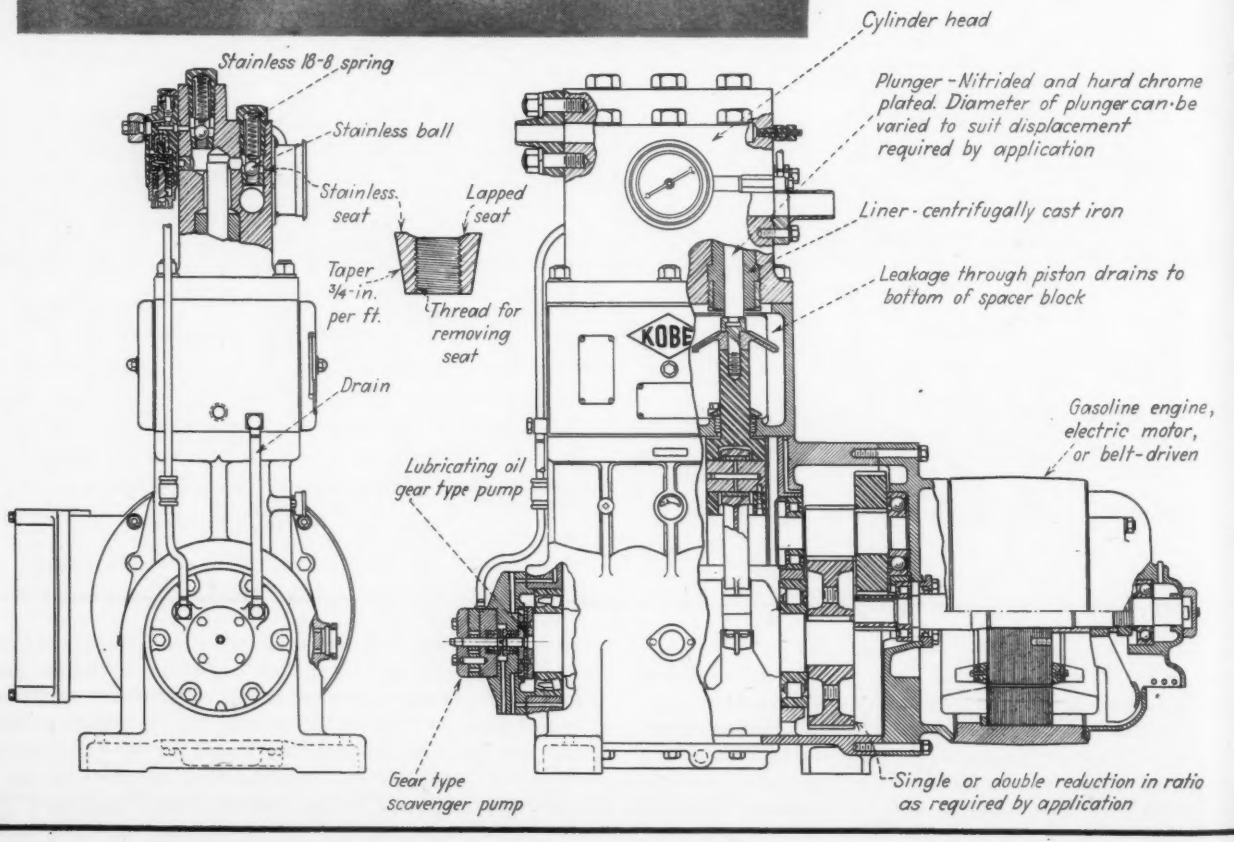


Control has inherent falling characteristics on a pressure-torque basis. Greatly increased pressures do not result in greatly increased torque, because the thin turbine blades are subject to "blow back" as the pressure rises. This condition acts as a safety feature for gears and other mechanisms driven by the device, because unusually large pressures will not result in forces sufficient to destroy the mechanism. Vibration conditions such as encountered in aircraft will not affect operation. The turbine blades vibrate, but their endurance limit is many times higher than that permitted by standard aircraft vibration tests, and the average torque from a vibrating blade is the same as that produced by a still blade. Cold shocks such as 100 deg. F. do not affect calibration. Heat shocks of 200 deg. F. in excess of the control point have no effect.

Different-Sized Plungers and Liners Vary Pump Capacity

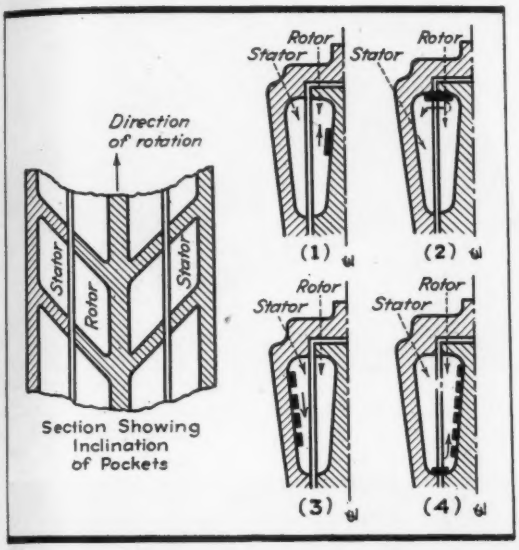


BY UTILIZING different diameters of plungers and liner bores, a wide range of capacities is available in this hydraulic pump developed by Kobe, Incorporated. For capacities in lower ranges, pump is equipped with a 7½ hp. motor; for larger capacities a 40 hp. motor is furnished. The unit is also supplied for belt drive. Single- or double-reduction gears are installed as required by the application. No plunger packings are used as design relies on close tolerances to minimize leakage between plunger and liner. The small amount of oil that does leak through is drained by gravity to the sump and returned to the suction side by a gear pump driven directly on the crankshaft. Another gear pump on the same shaft circulates lubricating oil to all bearing surfaces. Since the plungers are nitrided steel, hard chrome-plated and copiously lubricated, there is little wear in service.


Stainless 18-8 spring
Stainless ball
Stainless seat
Lapped seat
Taper ¾-in. per ft.
Thread for removing seat
Drain
Cylinder head
Plunger - Nitrided and hard chrome plated. Diameter of plunger can be varied to suit displacement required by application
Liner - centrifugally cast iron
Leakage through piston drains to bottom of spacer block
KOBE
Gasoline engine, electric motor, or belt-driven
Lubricating oil gear type pump
Gear type scavenger pump
Single or double reduction in ratio as required by application

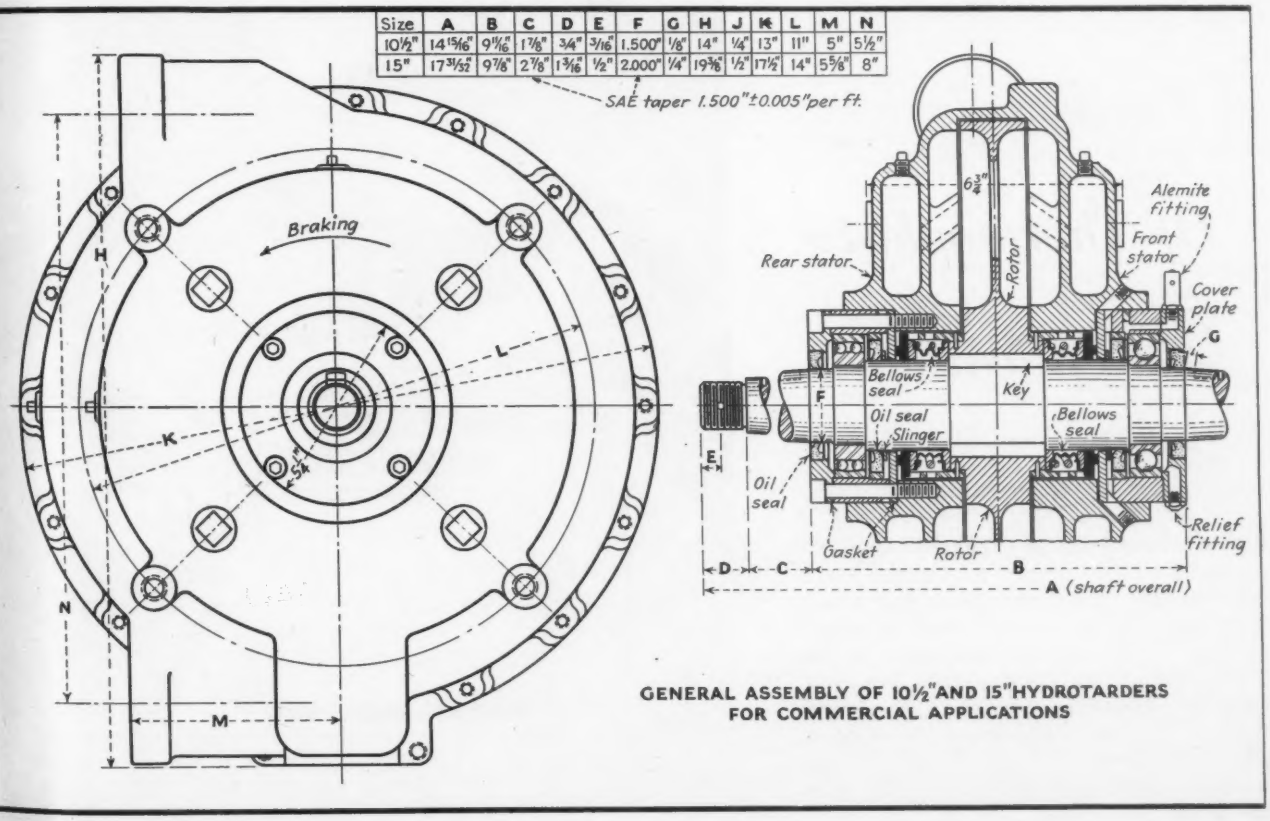
Fluid Friction Supplies Braking Resistance

CIRCULATION of water through a specially-vaned rotor and stator unit connected to a tank supplies braking resistance in oilwell and mining machinery, engines, trucking and transportation equipment. Known as the Hydrotarder, the unit was developed by Parkersburg Rig & Reel Company. It does not replace mechanical brakes, but operates in conjunction with them. Mechanical brakes are used for stopping and holding, whereas the Hydrotarder acts as a governor to prevent runaways. Shocks and jars are eliminated; wear and brake maintenance reduced. Resistance increases more rapidly than speed.

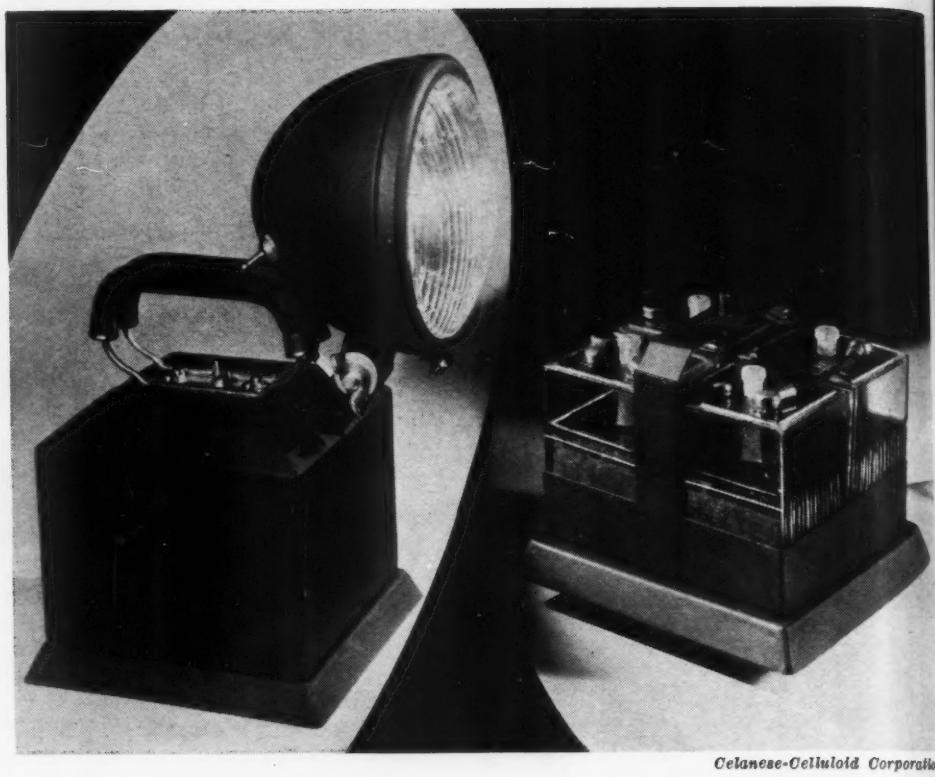


Pockets or buckets are on both side faces of the rotor and both side walls of the stator. The pocket partitions are inclined opposite to the direction of rotation. Cool fluid is supplied to the pockets by nozzles. Operation can be illustrated by considering a single slug of water in a single rotor pocket. As the rotor turns, the slug is thrown radially and circulates out of the rotor pocket into the stator pocket in the course of which it is cut by the stator pocket partitions. It is again cut when it returns to the rotor after being forced to move radially inward. The accompanying agitation plus the energy lost in fluid friction converts hydraulic energy into heat. Instead of a single slug of water, there is a continuous circulation. When reversing, pocket walls slip through fluid, offer little resistance.

Size	A	B	C	D	E	F	G	H	J	K	L	M	N
10½"	14 15/16"	9 11/16"	1 7/8"	3/4"	3/16"	1.500"	1/8"	14"	1/4"	13"	11"	5"	5½"
15"	17 31/32"	9 7/8"	2 7/8"	1 3/16"	1/2"	2.000"	1/4"	19 3/8"	1/2"	17½"	14"	5 5/8"	8"



GENERAL ASSEMBLY OF 10½"AND 15"HYDROTARDERS FOR COMMERCIAL APPLICATIONS



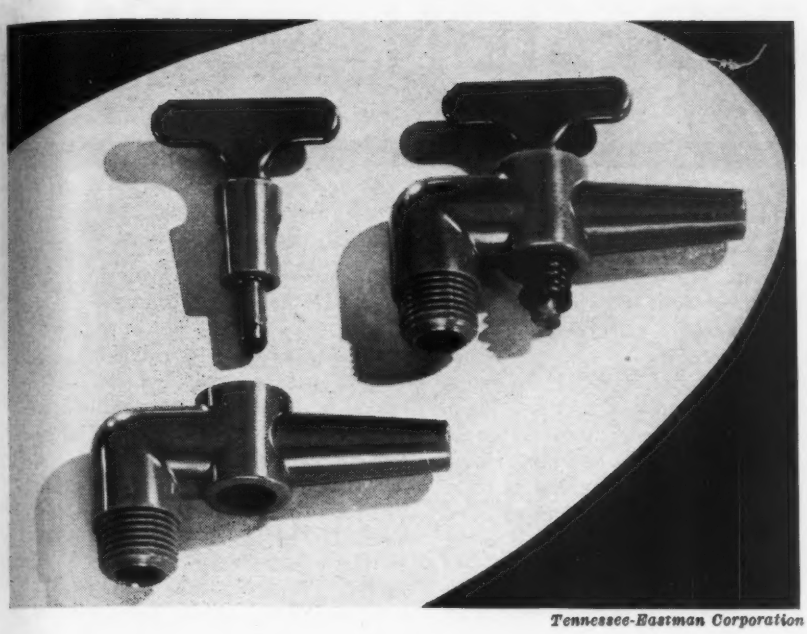
Celanese-Celluloid Corporation

Battery housing of transparent cellulose nitrate contributes greatly to weight reduction in the Dewar Manufacturing Company's 110,000 candlepower signal searchlight which weighs only 12½ lb. Availability of material, acid resistance, good impact strength, and lightness in weight led to the choice of cellulose nitrate instead of hard rubber for the battery housing.

New Product Designs Feature Variety Of Thermoplastic Application

Rohm and Haas Company

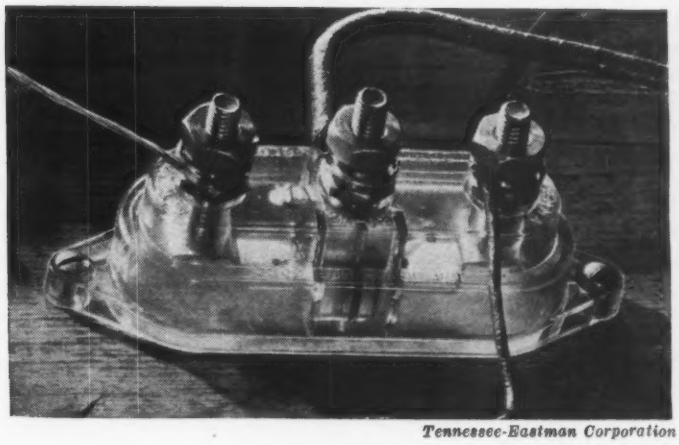
Celestial navigation instrument developed by F. H. Hagner for life-raft use is made entirely of methyl methacrylate. Instrument weighs about one lb. It eliminates need for almanac, sextant and compass, and combines a miniature of the celestial sphere, with names and precise locations of 22 navigational stars, with a world globe and all coordinates. Methyl methacrylate combines crystal clarity with lightness in weight and corrosion resistance.



Tennessee-Eastman Corporation

Stall cocks for controlling the vacuum on milking machines are now being injection molded of cellulose acetate-butyrate by the Continental Plastics Corporation. Ease of production, attractive appearance, good strength and ease of cleaning were the factors which led to the use of butyrate instead of brass.

Lightning arresters for use by the Signal Corps are now housed in transparent cellulose acetate. Glow of the small neon tube is visible during electrical storms, indicating a satisfactory connection between aerial and ground. Electrodes are sealed within the housing, and thus, protected against weather, dirt and insects. Housings are molded by Sterling Plastics Company and by L. S. Brach Manufacturing Company.



Tennessee-Eastman Corporation

One-piece pistol grips are being injection molded by American Insulator Company for Harrington and Richardson Arms Company. Material used is cellulose acetate-butyrate. Production costs are low. The material has high impact strength. Two grips are molded in a double-cavity mold in a 60-sec. cycle. Molded parts are cooled on a shrink plate to maintain proper tolerances for the pistol-mounting slot.

Rotary drill housings molded of cellulose acetate help reduce operator fatigue. Molded-in grip, smooth contours and lightness in weight are features of these housings molded by Reynolds Spring Company for Aro Equipment Corporation. Additional advantages of the plastic housing are high impact strength, resistance to chipping, good appearance.

Tennessee-Eastman Corporation

WARTIME DESIGN NEWS

Patent Life Extensions

A proposal whereby patentees who have been unable to realize benefit from their patents before their expiration may appeal for an extension of the patent's life has been written into a bill (HR 3762) laid before the House Patents Committee by Rep. William A. Rowan, Illinois Democrat.

Rowan's measure, which is similar to a bill before the Bone committee during the second session of the 77th (last) Congress providing new standards upon which the President might issue licenses under or take any patent for war use, also provides that patents so taken or so licensed without reasonable return to their owners may be extended for a period not to exceed 17 years. The bill thus appears to open a second avenue of recourse for the owner whose patent might be commandeered for war purposes.

Rowan's proposed bill provides that "Whenever, due to the operation of this act or due to unforeseen circumstances, valuable patent rights have lapsed or will lapse without the patent owners obtaining a reasonable reward or remuneration for their efforts expended in obtaining and holding such rights during the lifetime of the patents, the President shall have the power to extend said patents for an additional term not to exceed 17 years.

"Any owner of a patent may petition the President . . . for a renewal or extension of his patent, and upon showing that he has obtained and will obtain no benefit from such ownership during the lifetime of such patent and that the invention . . . is of great value, such patent may be extended. . . . Whenever such petition is refused, the petitioner may appeal to the U. S. Court of Claims, which shall have exclusive jurisdiction. . . ."

Protection Only Nominal

The section authorizing the President to extend patents affected by the wartime powers granted under the act would have virtually no effect on patents under which the President had merely issued wartime licenses without taking the patents for war use. The provision which allows the President to issue such licenses directs him to establish in each a "reasonable royalty," and limits the amount recoverable under any infringement suit resulting from such license to the royalty prescribed by the President. Thus, if a patent owner were to suggest that the President extend the life of a patent under which wartime licenses had been issued pursuant to this act—pleading as justification that the patent had not afforded a reasonable remuneration—such owner would in effect be asking the President to declare unreasonable and insufficient the "reasonable royalty" the President was required to establish in issuing the license.

If the President were to refuse to do this, the patentee would have no recourse under the first section allowing patent life extension, for it provides such extension only where the patent owner has not obtained from his patent a reasonable reward. Likewise the patent owner would be out of luck under the second provision allowing "any patent owner" to appeal for an extension, for this section provides that such appeal may be made only when the owner has obtained "no benefit" from his patent, and the President would argue that the "reasonable royalty" he prescribed in issuing the wartime license provided "some benefit."

Reconversion Now

Reconversion of American industry from war to peace has begun and even though its extent is and for some time to come will remain limited problems of the greater job which lies ahead—and policy decisions governing it—are now being decided.

The program for 2,000,000 electric irons for 1944 is the best guinea pig of the reconversion show thus far—at least in its interest to and effect upon the average citizen. Actually, it is far from the first reconversion program in a literal sense, for the plants which are working today on other products than those to which they originally converted are legion. But the change from manufacture of tanks to locomotives fails to muster the interest for civilians that is found in the change from a direct war product to a direct peace product—and a luxury item at that—such as electric irons, or the electric washing machines which are being programmed for next month.

Limited as it is, the existing reconversion program has spelled out answers to some problems which were worrying industry in general. The problem of how production on essential items was to be resumed, for instance, had many durable-goods producers worried. The problem of one company's getting a head start on the field was another. Some of these problems have been tentatively settled by WPB's iron program, which allows pre-war iron makers to accept or reject a quota of 43 percent of their 1940 production. This provision automatically rules out the producer who was not in the field before the war but who may have come up with some fancy ideas for new products in the hurly-burly of the "post-war planning for a better life for everyone" which has been popular recently. To keep manufacturers who happen not to be in a Class I labor shortage area or who happen not to be too heavily burdened with war contracts from stealing a march on competitors who are in labor shortage areas or who have no time for irons because of war work, WPB has ruled that a manufacturer unable to make his own quota of irons may have them made for him, so that he can put his own product on the market concurrently with his competitors. There are many other angles to the iron program similar to these, some of whose problems have been settled while others have merely been ducked.

Pricing Causes Trouble

What may kick up the first old-fashioned Washington feud since the Henry Wallace-Jesse Jones tangle brought a Presidential order for administrative figures to do their fighting in private is to be found in Economic Stabilizer Fred Vinson's directive regarding the pricing of essential civilian goods.

The directive, which was issued to govern WPB and OPA in price matters on products in which increased production was desirable, provided that where price incentive was deemed necessary or where price impediments had to be removed, a producer whose profits from

all operations were no more than double his average profits between 1936 and 1939, or who was operating at a loss, might charge a price composed of the production cost plus 2 percent. Producers whose profits were more than double the 1936–1939 figure would sell at cost.

This formula was originally aimed specifically at a local situation in the textile industry. Since its issuance in mid-December, OPA executives have, apparently with the full blessing of Vinson if not on his orders, construed it to apply to essential civilian goods produced under the growing reconversion program. At this point the conflict between WPB Chief Donald M. Nelson and Vinson, who have not been too friendly on several past issues, arises.

WPB people contend the directive was not intended to cover reconversion goods, and in one case, a WPB official refused to give an OPA official a list of such products to which the directive might apply. In mid-January, there were indications that Vinson might issue a new version of the directive to bring these goods specifically under its terms.

Among electric-iron producers, meanwhile, there were reports that all might band together and refuse to make irons on these terms, although it was not generally believed that all 26 producers would show such solidarity in the face of any real pressure, either from Vinson or from declining war orders.

The above rules would apply to price increases to individual producers or where varying increases in an industry were needed. The formula for increases on a uniform, industry-wide basis, is something else again.

Where such increases are permitted, the highest-cost producer in the program would not be allowed any markup over his production cost. Prices of lower-cost producers would be pro-rated to this figure. Where possible in such a case, any price increase would be minimized by an undisclosed pooling arrangement, which would insure that producers whose other profits are not excessive would be allowed the 2 percent markup. The purchasers' price of such an article would be the weighted average of the net maximum price to all producers. Any increase so awarded would be absorbed at subsequent stages of production and distribution "wherever absorptive capacity exists." In other words, a wholesaler with a favorable profit margin on other business might be required to sell such items at cost so as to absorb the manufacturer's increases.

Whether or not this directive provokes a Washington feud, it poses the pricing problem attendant on reconversion.

Electronic Standardization

The Army-Navy Electronic Standardization Agency henceforth will handle the standardization of electronic components started by WPB in conjunction with the American Standards Association. ASA has completed standards for 11 of 20 specified components, and will complete the remaining series of standards by March. These standards, when complete, will cover components which make up about 75 percent of all frequently-recurring parts of radios and other electronic equipment. The services indicated that the program would be continued not only for the duration but in peacetime as well.

Copper Cartridge Cases

Substantial cutbacks in small arms ammunition requirements and sizeable increases in the amount of copper available led the Ordnance Department to drop its steel cartridge case program for small arms and artillery on January 1 for a return to the favored brass case.

The steel-case program must be

Recent Model Junkers Plane Presented to Allies

U.S. Army Air Forces Photo

A young German flyer, either lost over the Mediterranean Sea or tired of the war, landed this Junkers 88 on an island held by the Allies, thus presenting the Army Air Forces with one of its most priceless prizes of the war—a new and totally undamaged enemy aircraft of recent design. With Allied markings, the plane was flown 12,000 miles to Wright Field where AAF experts went over it, seeking new and usable developments. The plane was particularly valuable for it furnished a check on reconstruction of earlier models captured in damaged condition. AAF experts rebuild captured planes but can never be certain that they have restored them exactly.

reckoned a success, despite its termination by Ordnance at the first opportunity. Probably the best proof of its success is the fact that Ordnance will continue to procure .45-cal. cartridge cases in steel rather than brass because in this size steel makes "a better case than brass." The .45-cal. case requires a shallower draw than any other and needs no taper, thus is easier to make than other small arms cases. It is less prone to stick in the chamber because it is shorter, thus overcoming one of the major problems encountered with steel cases. The .45 was the smallest steel-cased ammunition ever issued by the Army, although a smaller caliber steel case had been developed.

New Fabricating Techniques

Manufacturers of the steel cas profited by the program, for today th have considerably more knowledge deep-drawing and annealing of ste than they had when the war starte The Dura Division of the Detroit Ha vester Company, for instance, has a plied to its brass case production so of the techniques it learned while ma ing steel cases. In making brass case the company now starts with a coine cup rather than a drawn cup and pr duces the case with three draws rath than four. Heading and indenting the case are now performed on th same press.

The Germans, meanwhile, have go into the "ersatz-on-ersatz" stage in thi steel-case program. Their first ste cases were similar in manufacture our own—drawn and cupped. Mo recently the Nazis have taken to a ca made from a strip of thin steel spirall up from a base plate onto which it welded in much the same fashion paper tubes are made. These have bee used rather widely, and are surprisingl efficient, our Ordnance men say, properly protected from the element

Italian 20-mm. Gun Serves Two Purposes

U.S. Army Signal Corps Photo

This 20-mm. anti-aircraft gun was part of the beach defenses at Paestum, Italy, when it was captured by landing U. S. troops. While its guns are only half the caliber of the quadruple-mount Bofors gun widely used by our Navy, its carriage and operating mechanism is considerably larger and bulkier than that of the Bofors. This gun can be used for anti-tank work as well as against aircraft, and can be traversed in a broad arc up and down. Barrels appear to be readily interchangeable for extended firing, as are barrels of our own light anti-aircraft weapons. Slots at the base of the flash-hiders are ports through which gas can escape to cut down recoil. This is a modification of the muzzle-brake widely used on Axis weapons.

Materials

A substantial cutback in the produ tion of pig aluminum, which not lon ago was bitterly short, is the tip-off o the materials situation. For the uncon vinced, there are additional proofs tha it has eased to a point undreamed a year ago. The steady flow of relax tions of orders curtailing use of specif materials in specific products provide a growing flood of evidence daily. Eve the basic orders which established strin gent general rules concerning the use materials are being relaxed. In a fe instances, allocation control or othe restriction is imposed, but most of thes result not from a shortage of the mate rial but from a shortage of its finished form. In this category fall two recen orders. M-11-a, as amended, place lead-free zinc oxide under allocatio and stipulates permitted uses. Ship ments of two tons or less are free o allocation, but are confined to permitte uses. Order M-369 continues allocatio of pure tungsten and molybdenum in got, wire and sheet.

Zinc controls are relaxed unde M-11-b, as amended, with many use formerly permitted only on specific ap peal now permitted by general excep tions.

Vanadium restrictions as to deliver and sale were dropped under M-23-a as amended.

Cobalt may be delivered and sold freely under Order M-39, as amended

Money Well Spent

WHAT is it that makes one company "click" and not another? Why is it that one can safely predict even now, long before the war's end, that some manufacturers will meet with great success after the war, but others won't?

The answer is not easy. It is exceedingly complex. And no one factor will give the complete answer.

To be sure, a company must have cash and the ability to get out and borrow money. The expenses of reconversion may be heavy; and plenty of ready money will be useful and necessary.

Good management is another indispensable asset. Without it, a company will be doomed to ultimate failure. With it, success can be achieved, other things being equal.

But over and beyond these considerations, the company that hopes to go places must possess salable designs that it can put into production and place on the market when the right time comes.

The company that now has an outmoded product and expects to continue to make and sell it in the next few years is courting disaster, *for the years immediately following the war will be the most highly competitive in the history of American business.*

Only the company that keeps abreast of the times and that pays close attention to its product development can survive.

That is why it is false economy today to save pennies on research and product development. With the war's speeding up of new techniques and of the applications of new materials, now more than ever before is the period when research budgets should be amply expanded.

The engineering and development division of mediocre caliber is no asset to a company. It is, in fact, a liability, because it soon will prove itself barren of commercially valuable ideas and will lack the ability to create new designs that can command a market. It merely lulls management into a feeling of false security.

The only sensible thing is to have a research and product development organization composed of men of outstanding talent. Even that, however, is not enough, because such a group cannot do its best work unless it is given the facilities with which to carry out its important tasks.

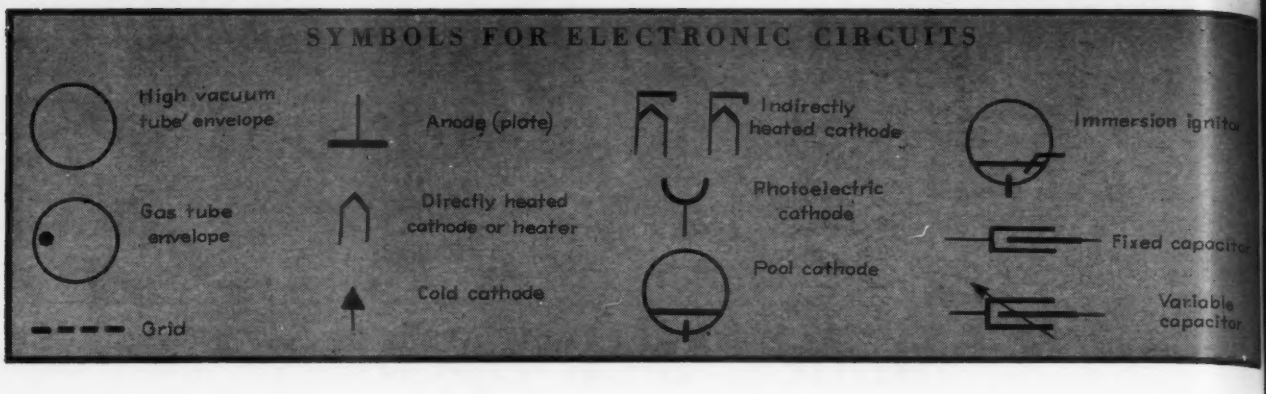
It has unfortunately been true in too many cases that a company willingly pays substantial salaries to qualified men worthy of their earnings, but pares to a pittance their requests for funds for experimental work. Results then prove disappointing or negative. And, shortsightedly, management will blame its research organization for lack of accomplishment.

Industrialists willing to risk their money only on a sure bet are likely to find their companies in an unenviable position. Success will go instead to companies operated along the lines expressed recently by the president of an aggressive organization:

"We don't worry whether a certain idea will end up in a profitable product. We do know that we have a high-priced, wide-awake engineering department. We respect its judgment. Our experience shows that it hits the nail on the head about one out of ten times. It takes only that one success to pay for all the failures and leave a handsome profit."

There is no better investment for the future safety and success of any company today than to give the research and product development department its head.

G. F. Nordenholt



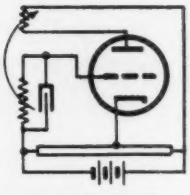
Basic Electronic Circuits For Industrial Functions

C. B. STADUM
Control Engineer, Electronics Section
Westinghouse Electric & Manufacturing Company

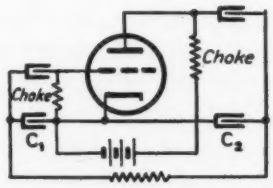
PRESENTING diagrams and descriptions of common circuits for current amplification, oscillators to produce desired current frequencies, arrangements for control of thyratrons and ignitrons, and phototube circuits. Triode, tetrode or pentode tubes amplify or step-up current or power of either d.c. or a.c. voltage. A single tube and its appropriate circuit can increase a small input signal to hundreds of times its original strength. Three general classes of tubes are used but it follows that the component parts of a circuit increase when used with a tube of more than three basic elements. Amplifiers in the circuits pictured all use triodes—tubes with anode, cathode and grid. This article concludes an electronic presentation which started in last month's issue of PRODUCT ENGINEERING, page 52.

OSCILLATORS

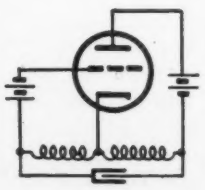
An oscillator circuit is a tube circuit characterized by its ability to produce and sustain periodic changes in voltages of a given frequency. This is done by making an amplifier tube supply its own input voltage. When this is done, the tube will produce from a d.c. source, an a.c. voltage of such frequency as is determined by the electrical constants of the oscillator circuit.



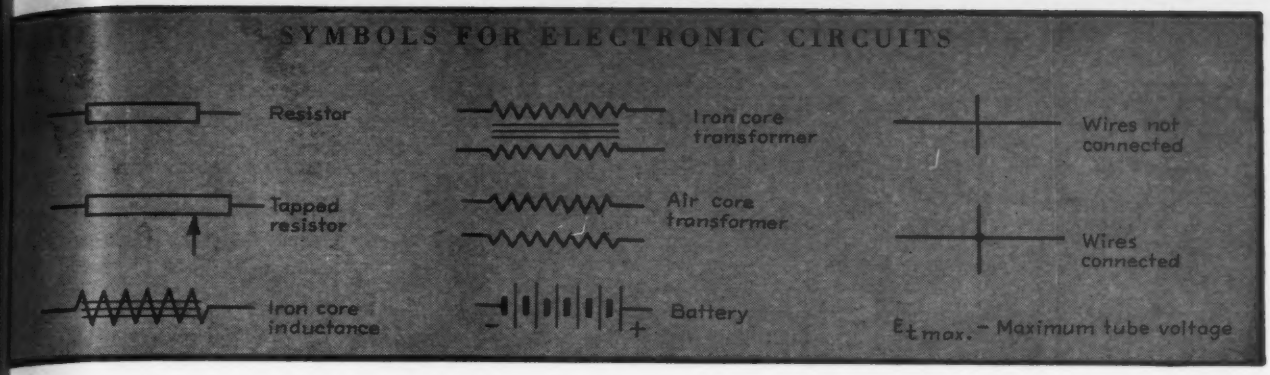
Tuned-grid oscillator. This is similar to the tuned-plate oscillator, except that the source of oscillations is in the inductance – capacitance resonant circuit in the grid. Oscillations are sustained by a portion of the plate voltage change being fed back to grid by magnetic coupling.

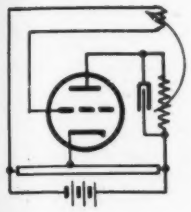


Colpitts oscillator. Depends on voltage fed back from plate circuit through capacitors No. 1 and 2. Does not oscillate as easily as feedback or Hartley oscillators because of necessity of varying both *C* No. 1 and *C* No. 2, if frequency is to be changed.

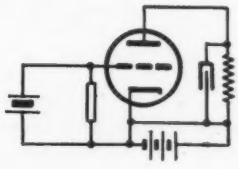


Hartley oscillator. Type of feedback oscillator in which the feedback is accomplished through a capacitor. Circuit is popular because it oscillates easily. Oscillator is useful for production of audio frequencies with good output wave form.



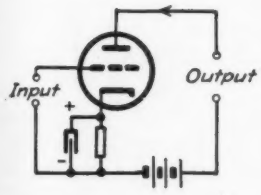


Tuned-plate oscillator. Contains a resonant circuit in the plate circuit of the tube. By mutual induction, a portion of the change in voltage in the plate circuit is fed back to the grid circuit with a phase relationship to sustain oscillation. Frequency is determined chiefly by inductance and capacitance in the plate circuit.

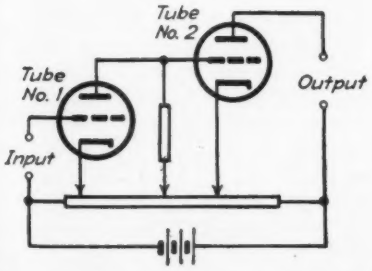


Crystal-controlled oscillator. Used to produce a constant frequency oscillation. An a.c. voltage appearing on a crystal starts the crystal vibrating at a given frequency which depends upon the physical characteristics of the crystal. If the applied voltage has a frequency of approximately the natural frequency of the crystal, the crystal vibrates and produces a constant frequency output. In the circuit shown, feedback from the plate resonant circuit because of the tube interlectrode capacitance, gives sufficient excitation for crystal to produce oscillations. Crystal control is used extensively in radio transmitters.

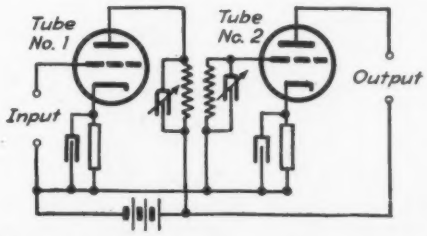
AMPLIFIER CIRCUITS



Single-stage amplifier. Its own proper grid bias is provided by the voltage drop across the cathode resistor caused by plate current flow. Bypass capacitor allows free passage of a.c. voltage around bias resistor to load. This type amplifier is used for low power audio output.



Direct-coupled amplifier. Input placed on grid of tube No. 1 is amplified and appears directly on grid of tube No. 2. Separate grid and plate voltage supplies are necessary for each tube, or a tapped single supply can be used. Used chiefly to amplify d.c. voltages.



Double-tuned, transformer-coupled amplifier. Consists of two single-stage amplifiers which utilize two circuits to couple from the plate of one tube to the grid of the next. Voltage change on tube No. 1 is transferred by mutual inductance to the grid of tube No. 2 by the transformer. Since the circuits are in resonance at one frequency, the amplifier passes only a narrow band of frequencies of very high magnitude. This type of amplifier is used to amplify, to a great degree, one particular frequency band and eliminate all others. Its greatest use is as intermediate frequency amplifier in superhetrodyne radios. Pentodes are generally used with this circuit.

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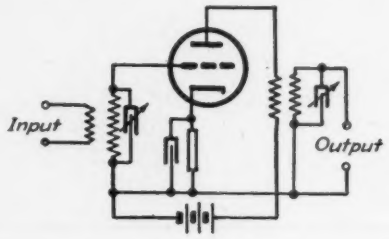
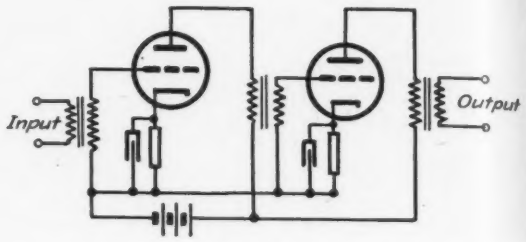
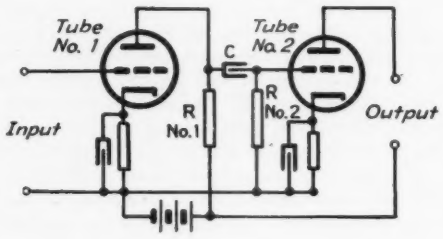
AMPLIFIER CIRCUITS (CONTINUED)



Single-tuned, transformer-coupled amplifier. Consists of a single resonant circuit which amplifies greatly a single frequency and eliminates all other. A variable capacitor obtains high amplification of any particular desired frequency. Pentode tubes are used. Application is generally for radio frequency amplifiers.



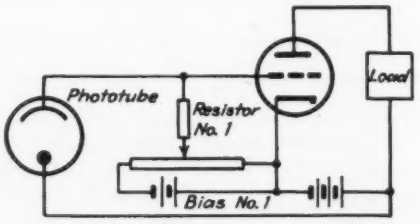
Untuned, transformer-coupled amplifier. Generally uses an iron core transformer to transfer audio frequencies from plate circuit of one tube to grid of the following tube. Each of the frequencies within audio range is amplified about the same amount. Gain is low to moderate. Used chiefly in output stages of audio amplifiers.



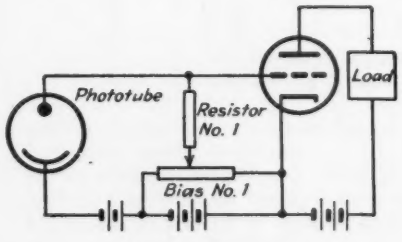
Resistance-capacitance coupled amplifier. Electrostatic coupling used between tube circuits. Change in plate voltage from tube No. 1 is transferred electrostatically through capacitor, C, and appears on grid of tube No. 2 across *R* No. 2. *R* No. 1 is resistor for supplying battery voltage to plate of tube No. 1. This circuit is used extensively as voltage amplifier for audio frequencies. Generally pentode tubes are employed.

CIRCUITS FOR PHOTOTUBES AND GLOW TUBES

Phototube circuits are used to convert light energy into useful electrical energy. Since the current that a phototube handles by itself is small, phototube is used with one or more amplifying stages.

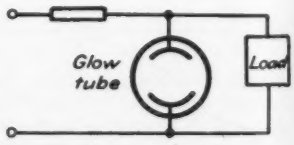


Forward d.c. phototube circuit. Load is energized when light impinges on the phototube. Normally the tube is prevented from conducting current by negative bias No. 1. When light falls on the phototube, current flows through the phototube causing a voltage drop across resistor No. 1 of such a polarity as to make the grid of the tube positive and cause it to conduct current.



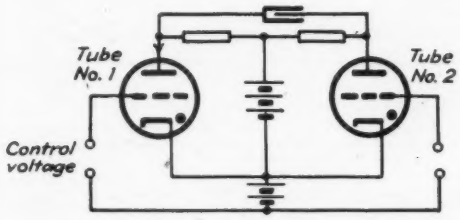
Reverse d.c. phototube. Load is always energized except when light falls on the phototube. Bias No. 1 is adjusted so that the amplifier tube or thyratron conducts all the time. When light shines upon the phototube, current passes through resistor No. 1 causing a negative voltage to appear on the grid of the amplifier tube, stopping current flow in the tube.

Glow tube circuit. This is the simplest type of d.c. voltage regulator. Since a glow tube has a constant voltage drop, any variation in line voltage appears across the resistor in series with the line and not across the load which is shunted by the glow tube. This tube of voltage regulator is used where only a small amount of power at constant voltage is required.

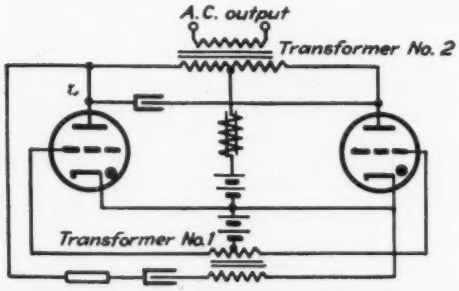


THYRATRON CONTROL

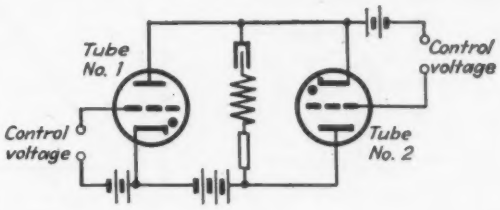
When using thyratron (gas-filled triode) control with d.c. supplies, the problem of control is more complex than with vacuum tubes. When a thyratron is once fired in a d.c. circuit, it continues firing regardless of the grid voltage. Special means are required to stop current from flowing through the tube. Opening the anode circuit by a switch or other method such as parallel, series, relaxation, and counter e.m.f. control can be used. When thyratrons are operated from an a.c. source, the tube stops conducting at the end of each positive half cycle.



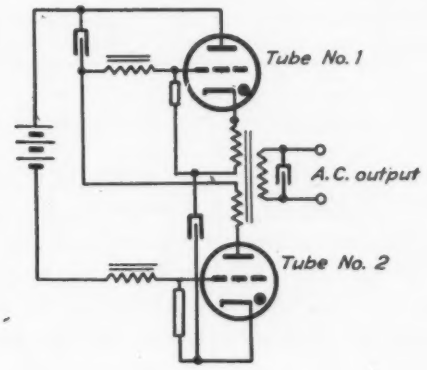
Parallel control. Consists of two thyratrons, or one thyratron and one switch. If tube No. 1 is firing, the capacitor will be charged as shown. When grid voltage of tube No. 2 is made positive, tube No. 2 fires extinguishing tube No. 1 by placing a negative voltage on the anode of tube No. 1.

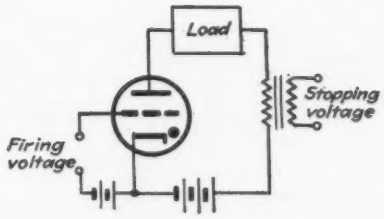


Parallel inverter. This is an application of parallel control of thyratrons. Where large amounts of a.c. power are desired from a d.c. source, the inverter is used. In this circuit, the thyratrons fire automatically by picking up through transformer No. 1, the necessary positive voltage to fire each tube alternately. A.c. output voltage is obtained from secondary of transformer No. 2.

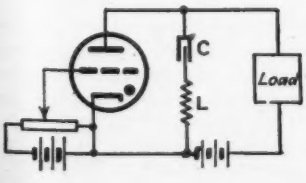


Series control. (Above) Used where a single impulse of current is required. When grid of tube No. 1 is made positive, tube No. 1 fires. It continues to fire until the capacitor is fully charged. By firing tube No. 2, the capacitor discharges and a voltage impulse of opposite polarity is obtained across the load. An application of this circuit is the self-excited series inverter shown below in which each tube simultaneously charges one capacitor and discharges another.





Counter e.m.f. control. Tube is fired by applying positive voltage to the grid of the thyratron. By applying to the anode, through a transformer or by any other means, a voltage of opposite polarity to the main supply voltage, the anode voltage on the tube drops to zero and the tube is extinguished. This type of control is used in circuits and in commutation in d.c. motors.



Relaxation control circuit. Tube is fired by applying positive voltage to the grid. After the anode current starts flowing, an oscillating current is drawn through the tube because of the capacitance and inductance in series. When the oscillating current starts to reverse, the tube is extinguished as it cannot carry reverse current. By applying a synchronizing voltage to the grid of the thyratron, the circuit can be used as a sweep oscillator for oscilloscopes.

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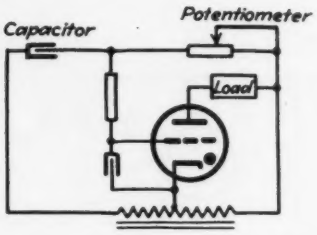
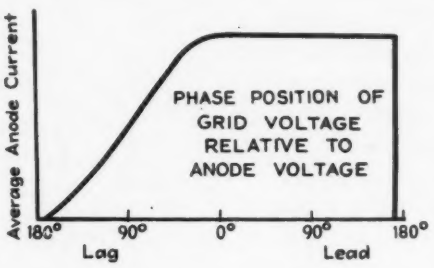
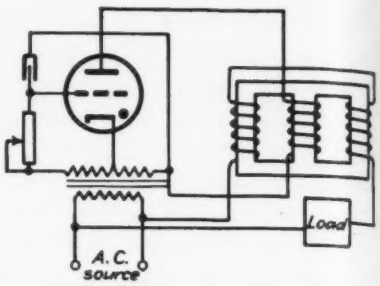
THYRATRON CONTROL (CONTINUED)



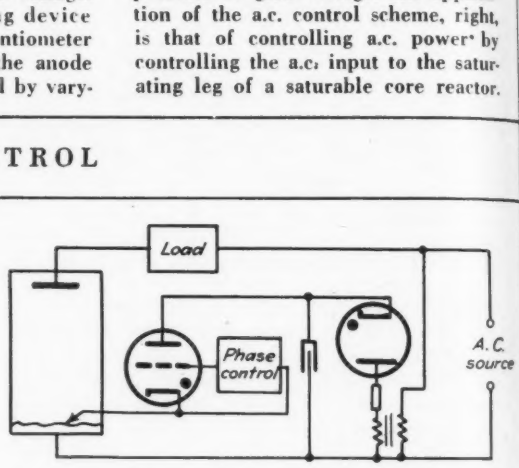




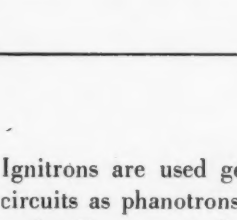
Alternating-current control. Makes possible precise control of very large currents from extremely small control equipment. Since a thyratron starts to conduct only when the anode and grid are simultaneously positive, the start of conduction can be accomplished at any point of the positive half of the a.c. voltage wave. The grid can be made positive at any instant by shifting the phase of the a.c. grid voltage relative to the anode voltage. By a suitable phase-shifting device like the series capacitor-potentiometer arrangement shown at left the anode current can be readily varied by varying the resistance in the potentiometer. The curve, center, shows the variation in anode current for various phase position of grid voltage. An application of the a.c. control scheme, right, is that of controlling a.c. power by controlling the a.c. input to the saturating leg of a saturable core reactor.

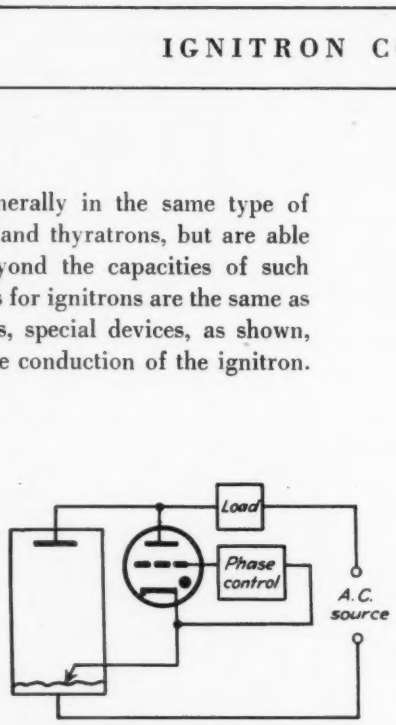
IGNITRON CONTROL

Ignitrons are used generally in the same type of circuits as phanotrons and thyratrons, but are able to handle currents beyond the capacities of such tubes. Although circuits for ignitrons are the same as circuits for other tubes, special devices, as shown, are necessary to initiate conduction of the ignitron.



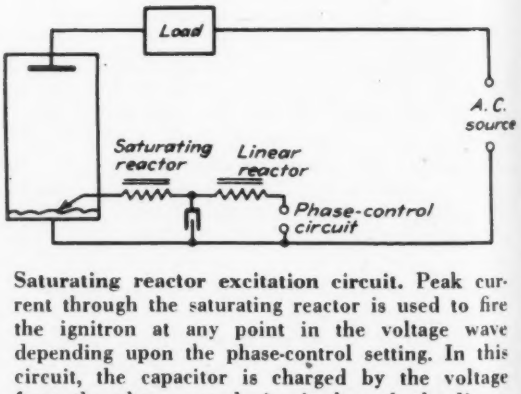
Capacitor firing. Can be used when the load current is light or the supply voltage is low. In this circuit, the phanotron charges the capacitor. At any desired point on the a.c. voltage wave, the thyratron tube, which has not been operating, starts to conduct. This discharges the capacitor through the ignitor, thereby firing the ignitron. The capacitor is charged during the negative half of the voltage wave and discharges during the positive half of the voltage wave at a point determined by the phase control on the grid of the thyratron.





Anode firing by switch or contactor schemes. Consists of merely making an electrical contact between the ignitor and the anode, above at left. When the switch is closed, a small current flows from the positive anode through the ignitor. When this happens, the ignitron fires dropping the anode voltage from virtually line voltage to about 15 volts. If the circuit is supplied from an a.c. source, firing takes place at the beginning of each positive half-cycle of voltage and stops after anode voltage becomes less than the arc drop of the tube.

Anode firing by thyratrons. Can replace anode firing by contactors. The thyratron can be made to start conducting at any point in the a.c. voltage wave by phase control on the grid of the thyratron. The ignition fires immediately after the thyratron fires. By using a heat-control circuit like that shown above at right, stepless control of current through the load is obtained.



Saturating reactor excitation circuit. Peak current through the saturating reactor is used to fire the ignitron at any point in the voltage wave depending upon the phase-control setting. In this circuit, the capacitor is charged by the voltage from the phase-control circuit through the linear reactor. When the capacitor is fully charged, the magnetizing current of the saturating reactor increases rapidly, causing the capacitor to be discharged suddenly through the ignitor. This circuit is used extensively for large power rectifiers.

Determining Endurance Limits Of Flexurally-Stressed Steel Members

FREDERICK FRANZ
Consulting Engineer, New Haven, Conn.

A method of evaluating the safety of flexurally-stressed, heat-treated steel members against the type of failure which originates below the surface from repeated stresses in excess of the endurance limit.

IF a beam made of homogeneous material having uniform unit strength is subjected to either steady, repetitive, or alternating bending stresses, it will start to fail at the outer fiber when the stress there becomes equal to the unit strength of the material. But if a beam made of non-homogeneous material, such as quenched and tempered steel having a non-uniform structure and strength, is loaded in bending, especially alternating bending, failure may begin at some point below the surface.

Non-homogeneous material may be stressed below its endurance limit at the extreme fiber, yet considerably above its endurance limit at some point below the surface where fatigue failure will probably start. This condition is caused by the variation in the endurance limit of the material at different points over the cross-section because of heat-treatment or similar reasons. Fig. 1 illustrates a typical example of such a condition.

During the last few years and especially since the advent of the N.E. steels, it has become a common practice to make hardness traverses of various grades of these steels. Fig. 2 shows a typical hardness traverse made on a 3 in. dia. bar of 0.30 percent carbon low-alloy steel, after quenching from the A_{c3} point and tempering at 600 deg. F. The Rockwell C hardness at the surface is 45, but this hardness drops rapidly so that ½ in. below the surface it is only Rockwell C 22. At the center it is Rockwell C 19. If hardness traverses for particular steels are not available, they may be plotted for various sections from Jominy hardenability tests as shown in the American Iron and Steel Institute booklet No. 7 on "Contributions to the Metallurgy of Steel."

There is a definite relation between the hardness number and the ultimate tensile strength of steels. The tensile strength in lb. per sq. in. is nearly equal to 500 times the Brinell hardness number. Greaves and Jones showed this, and numerous tests have since been made to corroborate these relations for Brinell, Rockwell and other hardness numbers, and the tensile strength of steel.

The dotted line in Fig. 2 was drawn from such a table. The ultimate tensile strength corresponding to each hardness number was simply plotted on a suitable scale. This line depicts the tensile strength of various fibers of this steel bar as hardened and tempered at various points in its cross-section. The unit strength of the steel bar is

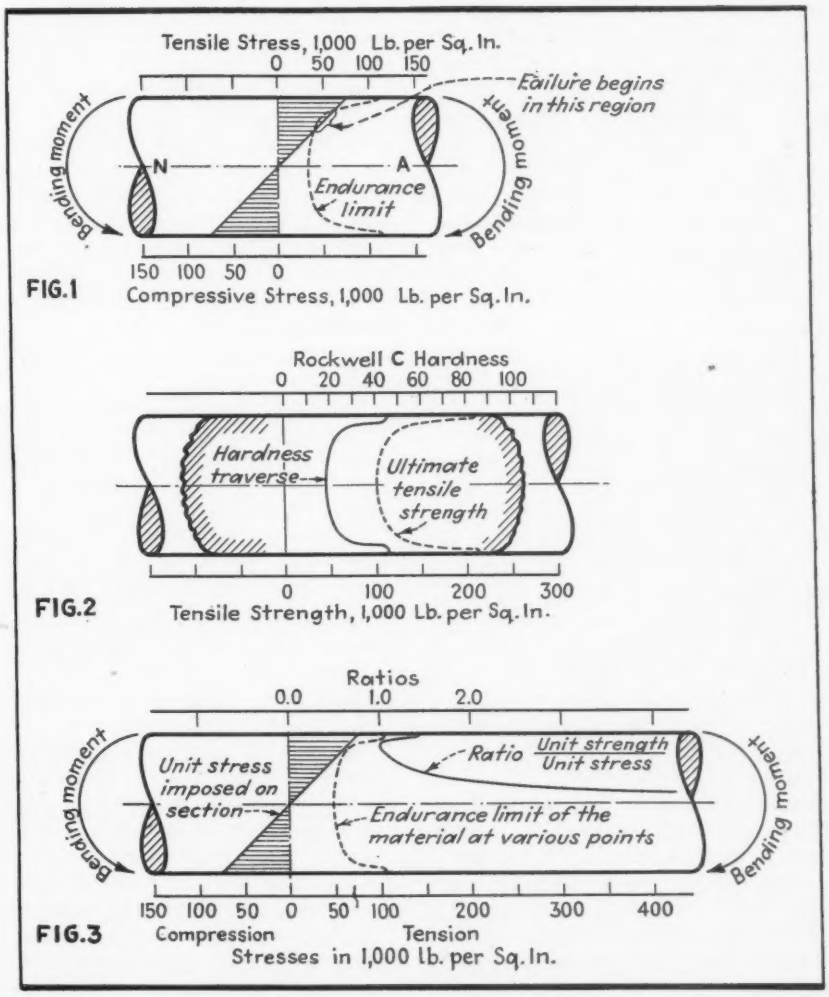


Fig. 1—Stresses in a homogeneous beam under pure bending. Fig. 2—Hardness traverse of a 3-in. quenched and tempered bar with corresponding tensile strength. Fig. 3—Relation between endurance limit and unit stress, and their close subsurface approach.

212,000 lb. per sq. in. at the surface; 115,000 lb. per sq. in. at a point ½ in. below the surface, and 100,000 lb. per sq. in. at the center.

Tests by Moore and others working in the field of fatigue of metals have shown that the endurance limit of steels is close to one-half of the ultimate tensile strength, barring notch effects and dimensional stress raisers. Replotting of the dotted line in Fig. 2 to one-half of its value at all points, as in Fig. 3, will give the endurance limit curve of the steel in this member at various points. Thus its endurance limit at the hard surface is 106,000 lb. per sq. in. whereas its endurance limit is only 57,000 lb. per sq. in. at a point ½ in. below the surface.

The curve of actual stresses imposed on all unit areas is transferred from Fig. 1 to Fig. 3. The unit strength is compared with the unit stress for all points across the diameter by dividing the strength by the stress. The third curve is the result and illustrates the fact that whereas, at the surface, a fair margin of safety exists (ratio 1.42/1.0), and near the core an ample margin exists indicating an indefinite life, at a point ¼ in. below the surface the endurance limit and unit stress are just about equal (ratio 1.0/1.0) indicating a definite life of about one million cycles. This failure will begin, not at the surface, but below it. If the unit stress were above the endurance limit stress, reference to the S-N endurance limit curves for the particular material would reveal the expected life of the bar. This would occur for example in a straight .30 percent carbon steel having the same surface hardness (RC 45) since straight carbon steels of a given carbon content are not as deep-hardening as alloy steels of the same carbon content, other facts remaining the same.

Carburized steels show a more exaggerated unit strength-unit stress curve because of the relatively greater unit strength of the surface of the case.

Diesel Engine Design Trends

"THE diesel engine never reached its maximum usefulness until adopted by the automotive industry under pressure of war and produced on assembly lines with greatly increased speed and with consequent reduction in price," said Edward C. Magdeburger, head engineer, Navy Bureau of Ships, in discussing diesel engine design trends on the basis of war experience at the recent war engineering annual meeting of the Society of Automotive Engineers in Detroit. "This process . . . robbed the diesel engine of its aura of craftsmanship, . . . but it gained immensely in adaptability. This is a revolutionary process of great importance to the entire industry. . . . Future development will most likely follow an entirely different course. . . . The advantage of mass-production forced the development of units of greater number of cylinders since only by so doing could the Navy obtain the desired ranges of engine output. . . .

"Use of gears became necessary with higher engine speeds and . . . was not accompanied by any tooth failures or excessive wear which were expected to result from the shock of cylinder explosions. . . . With gears vindicated of any suspicion of unreliability, the use of lightweight high-speed engines will, no doubt, be greatly accelerated. Geared aircraft engines have been standard practice for some years and contributed to the development of a lightweight engine as well as of an efficient propeller.

"Fuel-injection equipment originally had to be classified as expendable or replacable material to prevent tinkering by incompetent hands and therefore its design was 'frozen' to reduce the number of spares required. This lack of competition and incentive will and does retard its development. The cost of the present injection equipment represents too high a part of the total cost of the diesel engine and therefore new and simpler methods of solving this problem are definitely needed. . . .

"Combustion research was also eliminated to a great extent under the pressure of war with the result that combustion chamber characteristics which would not have survived normal competition continue in use. . . . High fuel consumptions at higher speeds can hardly be explained by speed alone and apparently reflect the lack of such research.

"Ballistic effect of exhaust as an aid or even the principal means of inducing supercharging has not been thoroughly appreciated despite the efforts of Buechi, Kadenacy and others. . . . Greater utilization of the kinetic energy in the slug of exhaust gases passing through the exhaust valve or port at the moment of its opening will lead to greater charge or supercharging effect of cylinders. . . . Practical considerations require a single exhaust manifold, even for 16-cylinder engines. . . .

"Scarcity of strategic materials and shortage of manpower . . . brought with them a number of different problems and have taught us many a lesson in economy on a national scale. . . . It was this . . . impetus which finally overcame all objections to porous chromeplating of cylinder liners, so that the problem of suitable wearing surface can be permanently divorced from that of the structural strength required. . . .

"Steel crankshafts are one of the most difficult parts to obtain under prevailing conditions. . . . The experience of the Ford Motor Company . . . has been used to produce a large cast-steel crankshaft for experimental purposes. Crankshafts welded from small drop-forged component parts have also been successfully produced and installed. A mechanically built-up crankshaft without the handicap of added weight of the existing type with shrunk-in journals may be the solution of this problem. . . . At present the most widely used remedy to the crankshaft bottleneck is the shaft cast from such patented compositions as Proferall and Meehanite.

"Torsional vibration seems to be still the perennial sub-topic of all discussions on diesel engines. . . . The 'hope of the world' at the moment is the Chilton 'bifilar' or pendulum damper. . . . There is no doubt as to the effectiveness of such a damper. The question is only how to avoid the false Brinelling effect resulting from the very small motions of these rollers under heay load. This apparently is very similar to the experience of the automotive industry with ball and roller bearings during shipment of automobiles on trucks and in freight cars. The fact must not be overlooked, however, that the higher the speed of rotation of an engine and the larger the number of cylinders or crankthrows it has, the more criticals will fall within the operating range and the more urgent, therefore, becomes the need of reliably controlling them.

"Vibration and noise are also the inevitable consequences of going to higher speeds and I believe we are approaching, if we have not already reached the point, where continuous presence of the operator in the engine room may be injurious to his health on account of noise."

Properties and Characteristics Of Melamine-Formaldehyde

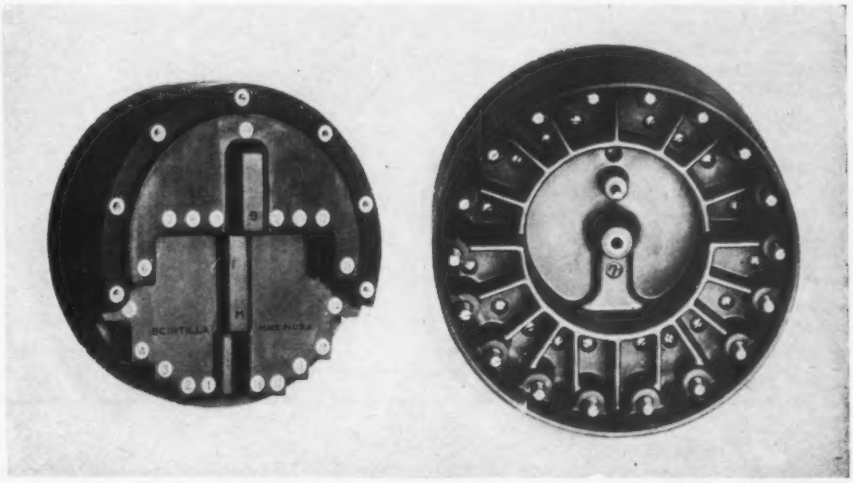
Melamine-formaldehyde resin, one of the newer thermosetting plastics, has been found to be particularly useful for electrical applications and for use where impact strength and good alkali, moisture, abrasion and flame resistance are desirable. This article discusses the properties of various forms of the material and some recent applications.

ONE of the most recent members of the thermosetting family of plastics, melamine-formaldehyde resin has characteristics that are particularly valuable for molded parts in which good electric properties are desired. For example, melamine-formaldehyde has excellent arc resistance and in this respect is superior to natural rubber as an insulator. The material also has high dielectric strength. Other desirable characteristics are high impact strength, nontoxicity and resistance to alkalies, abrasion, heat, moisture, organic solvents and weak acids.

Some idea of the relative arc resistance of melamine-formaldehyde can be formed on the basis of recent tests made on several representative plastics by the laboratories of the Plastics Industries Technical Institute. Electrodes were spaced 0.200 in. apart and the test was run at 50 milliamperes. Results showed that the surface of cast phenolics broke down in 1.2 sec. and that of molded urea in 10.5 sec. After 900 sec. the test on molded mineral-filled melamine was discontinued because the material showed no breakdown.

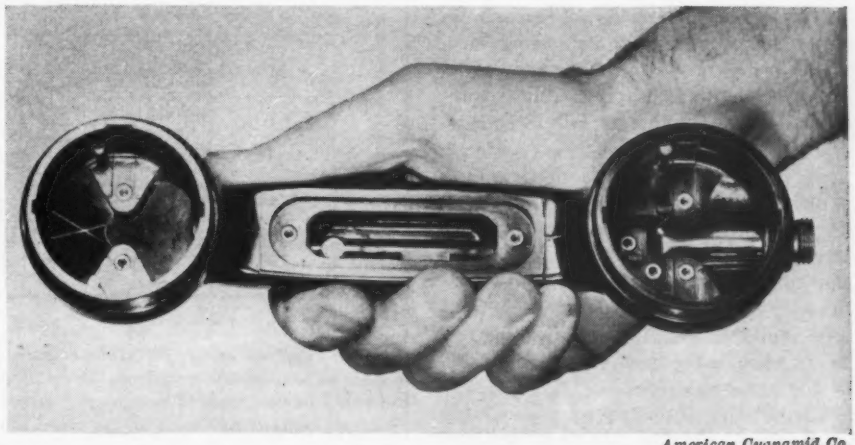
In the first melamine-formaldehyde compounds developed, brittleness and high shrinkage on aging were encountered. This accounted in part for the slow commercial application of melamine-formaldehyde resins. When metal inserts were required in molded parts, microscopic cracks sometimes developed. However, these difficulties were finally overcome by modifying the resin in manufacture.

Melamine-formaldehyde resins are almost always combined with fillers when used as molding compounds. Alpha-cellulose pulp filler produces a molding material similar in appearance, range of color and moldability to urea. This type of filled resin, as compared with ureas, is harder, shows greater resistance to heat, boiling water and dilute acids and alkalis, and has unlimited color range. When the resins are combined with a chopped-fabric filler, molding materials result that are noted for impact resistance, flexural strength, low water absorption and general inertness. Mineral-filled compounds have the best electrical properties of the three combinations. These are also generally used for molding around inserts because mineral-filled compounds have low shrinkage compared to that of the first two groups. The fabric- and mineral-filled melamines do not have the color range that is possible with the alpha-cellulose type.



American Cyanamid Co.

Mineral-filled melamine compounds are satisfactory for molded ignition parts, such as this distributor head, because outstanding electrical properties are necessary.



American Cyanamid Co.

Heavy-duty telephone handset molded of rag-filled melamine, an experimental molding for the U. S. Army Signal Corps, is featured by high resistance to shock.

Range of Properties of Melamine-Formaldehyde Compounds *

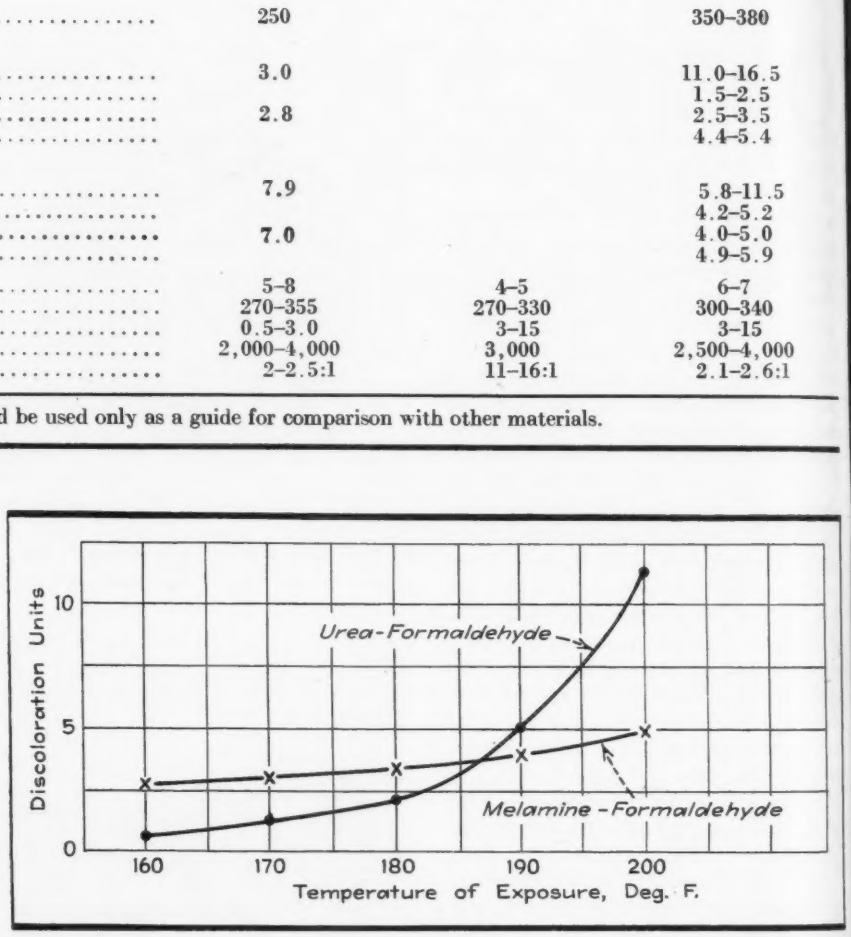
Properties	Alpha-Cellulose	Chopped-Fabric Filled	Mineral-Filled
Specific gravity	1.45–1.50	1.500–1.506	1.76–1.98
Flexural strength, lb. per sq. in.	14,800–16,500	12,000–16,800	8,820–14,000
Deflection, in.	0.067–0.074	0.055–0.070	0.28–0.45
Impact strength, izod, ft. lb. per in.	0.268–0.279	0.6–1.1	0.268–0.340
Tensile strength, lb. per sq. in.		7,300	5,942
Compressive strength, lb. per sq. in.	27,000	31,000	
Deformation, in. per in.		0.08	
Water absorption, 24 hr. at 25 deg. C., percent	0.7–1.7	0.75	0.10–0.30
Heat resistance, deg. F.	210		300–400
Heat distortion, deg. F.	385		
Arc resistance, sec.	125	100–130	130–187
Dielectric strength, short time, volts per mil.	340	170–300	340–730
Dielectric strength, step-by-step, volts per mil.	250		350–380
Power factor, 25 deg. C., percent			
60 cycles	3.0		11.0–16.5
$5x10^4$ cycles			1.5–2.5
10^6 cycles	2.8		2.5–3.5
$35x10^6$ cycles			4.4–5.4
Dielectric constant, 25 deg. C.,			
60 cycles	7.9		5.8–11.5
5×10^4 cycles			4.2–5.2
10^6 cycles	7.0		4.0–5.0
$35x10^6$ cycles			4.9–5.9
Mold shrinkage, mils per in.	5–8	4–5	6–7
Molding temperature, deg. F.	270–355	270–330	300–340
Molding time, min.	0.5–3.0	3–15	3–15
Molding pressure, lb. per sq. in.	2,000–4,000	3,000	2,500–4,000
Bulk factor	2–2.5:1	11–16:1	2.1–2.6:1

*Data given are not absolute and should be used only as a guide for comparison with other materials.

Transfer molding improves the forming of rag- and mineral-filled melamine-formaldehyde compounds, particularly where intricate shapes are concerned.

One widespread use of mineral-filled melamine compounds is in aircraft ignition parts, because outstanding electrical properties are required. This was one of the first war-equipment applications of the material. Electrical characteristics plus moisture resistance have been important factors in the choice of cotton-filled melamine-formaldehyde for circuit breakers. Impact strength is also an important consideration in equipment of this kind. This same type of material is used in food trays molded with individual compartments which have been extensively used by the armed services.

The alpha-cellulose type material is used extensively for marine tableware. Plates resist scratching because of surface hardness. Moisture and heat resistance are such that hot liquids do not affect the material. Shock resistance allows dishes and trays to be handled roughly, compared to china, without breaking them. Melamine is non-toxic and does not affect the taste of food. In many respects, melamine-formaldehyde has characteristics that may be particularly useful in molded parts for processing machinery. The alpha-cellulose material when used for buttons resists the heat and moisture of laundering and the possibilities of corrosion inherent in modern decontamination processing.



American Cyanamid Co

Rate of discoloration of alpha-cellulose filled melamines and urea-formaldehyde molding compounds calculated in arbitrary units proportional to visual estimation is indicated in this chart. The range of discoloration is small, 2 to 4 units being detectable by close comparison with an untested duplicate moldng.

Laminating compounds containing melamine resins have high heat, flame and arc resistance. Such compounds work well for paper, wood laminates, asbestos and glass fiber under either high or low pressure. Melamine hot-set adhesives are a recent development for bonding both bag-molded and flat plywood.

Combinations of melamine- and urea-formaldehyde resins result in products that are superior in heat and moisture resistance to those of straight urea resin. Phenolic laminates with a melamine surface have arc resistance, hard surface, heat and alkali resistance and color range. Diffusing screens are made

of 100 percent laminated melamine resins in combination with an alpha-cellulose type paper.

Finishes offer a wide field for melamine-formaldehyde resins. Formulations of finishes that contain these resins are faster-drying and more abrasion, heat and moisture resistant than formulations that do not contain these resins. In baking finishes the resins reduce baking time.

Another interesting application of melamine-formaldehyde resins is their use in the production of wet-strength papers such as those used for processing military equipment. Cellulose fibers treated with 3 percent of the resin have been found to have increased wet strength ranging from almost nothing to as high as 50 to 60 percent of the dry strength.

The range of products incorporating melamine-formaldehyde resins with generally satisfactory results, besides those mentioned, includes terminal blocks, closures, display boxes, housings, lighting reflectors, instrument dials, control handles and knobs, meteorological instruments and surgical items.

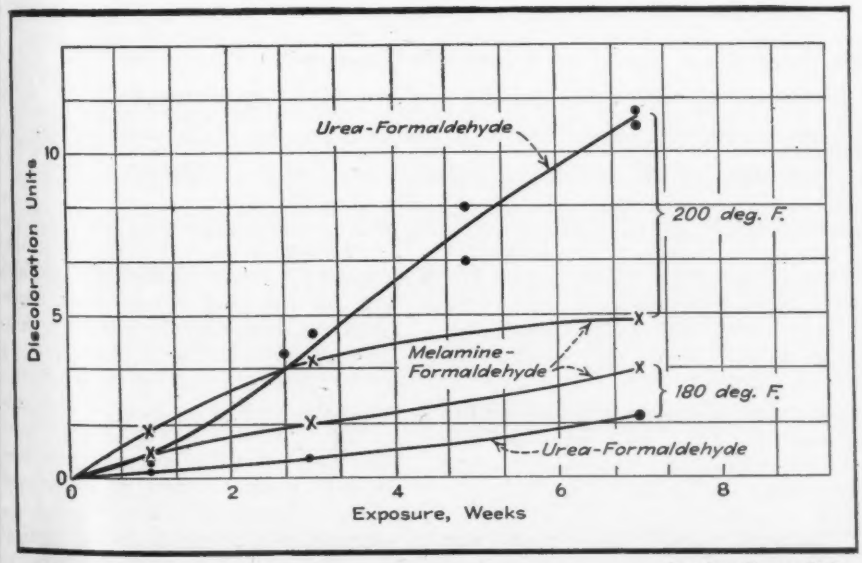
As yet, melamine-formaldehyde has not been used for radio applications because no filler has yet been found that will produce a compound with a low power factor at high frequencies that is better in service or less expensive to produce than existing materials, such as phenolics.

In designing any molded plastic part, and this applies to the melamine-formaldehyde compounds as well, it is desirable to surround inserts with a sufficient thickness of compound to overcome cracking. In general, the thickness of material around the insert should at least equal that of the insert. Points of discontinuity, such as sharp corners or inserts, rapid changes of section and long, completely buried inserts, are undesirable. Uniform wall thicknesses are recommended because a smooth, unimpeded flow in the mold and an even cure are essential. Generous fillets are also highly recommended.

Many war uses of melamine-formaldehyde are military secrets, particularly from the standpoint of operating results. Such applications incorporate the latest developments in compounds and molding technique and even some of these cannot be mentioned at this time. It is safe to assume, however, that for post-war activity the knowledge of melamine-formaldehyde resins and compounds gained during the war added to results of further investigation and development will clearly define the field for this material.

American Cyanamid Co.

Circuit breaker molded of rag-filled melamine to fill U. S. Navy specifications.



American Cyanamid Co.

Discoloration of alpha-cellulose filled melamine-formaldehyde and urea-formaldehyde moldings exposed for seven weeks at various temperatures is shown in this chart.

Vega Aircraft Corporation

Remote control power-operated "chin turret" increases effectiveness of new B-17G bomber.

Special Design Features In Airplane Motors

WILLIAM H. FROMM
Motor Division, The Dumore Company

Modifications and departures from standard fractional horsepower motor design that have been developed to meet the specific performance requirements of aircraft parts and accessories. A check list is included covering data and specifications needed to design or to select a satisfactory aircraft motor.

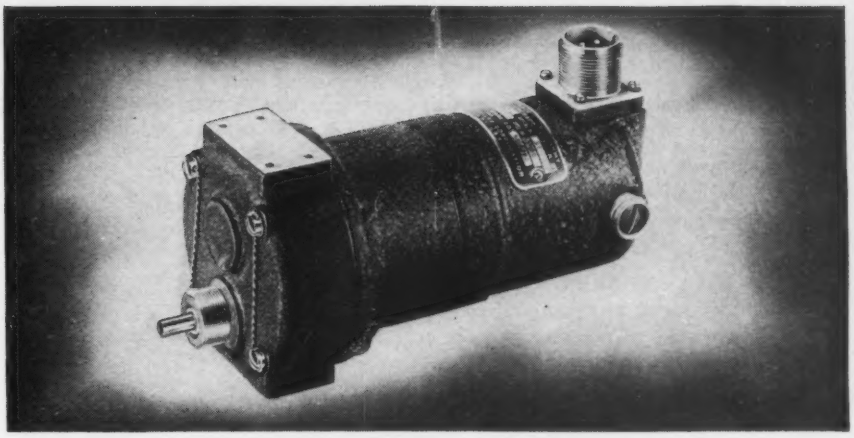
THERE are virtually no standard motor applications for the aircraft industry. Each new application is a special one. If the application does not demand a special new motor, it ordinarily demands at least special modifications of a standard motor. Many design features have been developed to meet specific performance requirements.

MAGNETIC BRAKES have been developed to provide a quick stop for such mechanisms as cowl flaps, inter-cooler doors and wing flaps where it is essential to prevent jamming and damaging of the driven part, and over-run of limit switches. The principal types of brakes used are the disk and internal expanding designs; both are actuated by a brake solenoid. When the motor is in operation, the solenoid is energized and keeps the brake off. When the motor stops the solenoid releases and a spring operates the brake.

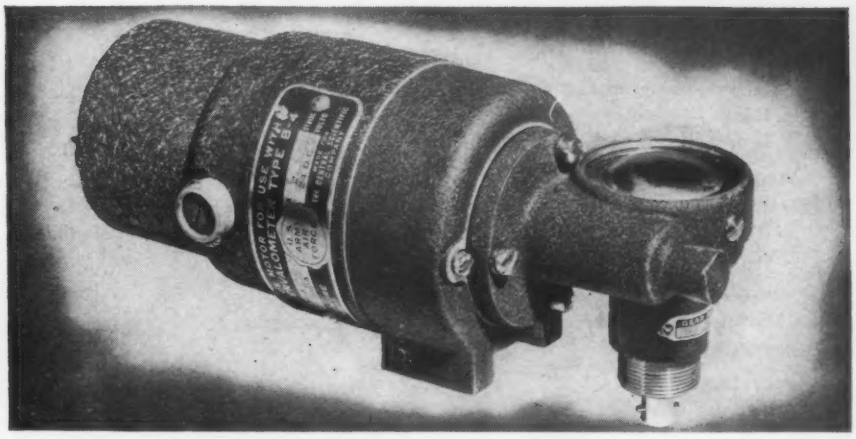
MAGNETIC CLUTCHES are provided where it is desirable to allow the drive to slip at a predetermined torque, to provide for manual operation of the driven mechanism in an emergency, or to disengage the armature from the load and allow the friction of the driven mechanism to stop itself. Ordinarily a disk-type friction clutch is energized by motor current to hold the disks together when the motor is on, and released by a spring to allow the armature to coast to a stop when the motor is off. Frequently a combination of brake and clutch is used. This arrangement, an elaboration of a simple brake application, makes it necessary for the brake to absorb the momentum of the armature, which coasts to a stop, the brake acting

on the driven mechanism only. By reducing the brake service, the clutch and brake arrangement appreciably extends the life and reliability of the brake.

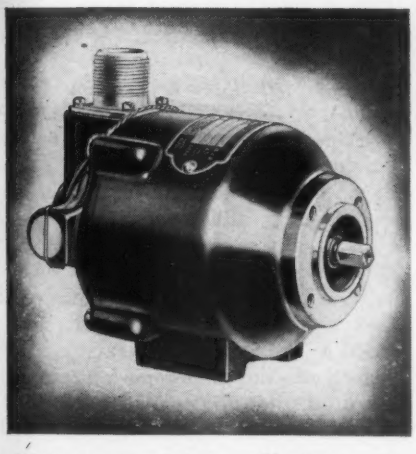
THERMAL OVERLOAD PROTECTION has evolved from the increasing interest in protection of motor windings against overheating from prolonged stall or overload. One type of thermal overload protector is a built-in bi-metallic disk with a heater coil which carries motor current. This protector is sensitive to the temperature of the windings and when that temperature reaches a predetermined point the protector opens the circuit. When the temperature lowers past that point the circuit is automatically closed and motor operation begins again. This cycle repeats until the condition causing the stalling or overloading has been corrected. It is a difficult problem to achieve a compromise which will permit the motor to stay on the line in an emergency until the last possible moment before permanent damage is done to the windings.



Small motor for operating aerial camera.



Electric governor-controlled intervalometer motor.



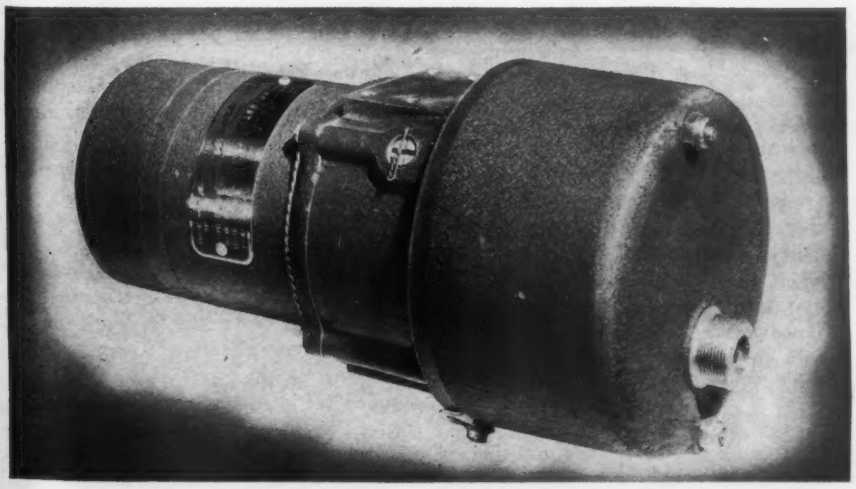
Explosion proof de-icer distributor valve motor has flame-sealed bearings.

LIMIT SWITCHES can be built into the motor to limit travel of the output shaft. For example, after the motor has made the predetermined number of revolutions to open a cowl flap, the limit switch connected in series with the motor opens the circuit and the motor stops. Variation of the limit can be arranged by installing the switches so that they can be adjusted from the outside of the motor housing.

POSITION INDICATORS are special features for installation on aircraft accessory motors. A potentiometer built into the motor and geared to the output shaft varies the amount of current flowing to a position indicator on the instrument panel, thereby translating the number of r.p.m. which the output shaft has made into the position of the device being operated by the motor.

EXPLOSION-PROOF motors with specially designed housings and flame-sealed bearings have been developed for operation in hazardous gas atmospheres where there is danger of a spark or explosion within the motor being propagated outside the motor. These motors are larger and heavier than the equivalent motor in a non-explosion-proof type.

ELECTRIC GOVERNORS. Centrifugal switches of the vibrating-contact type have been applied to motors where close speed control is required. The speed variation with a governor is generally held to plus or minus three percent, but on some jobs it is actually held to plus



Cowl flap motor with built-in limit switches and external adjustment levers.

Table I—Aircraft Motor Data and Specifications

A. VOLTAGE.
1. 12 or 24 volt nominal but what will requirements be for variation? For instance, from 11 to 14.5 volts, or from 22 to 29 volts? From..... to .....

B. HORSEPOWER OR TORQUE AT OUTPUT SHAFT.
1. Geared motors usually have torque specified in lb. ft., lb. in. or oz. in..... Torque curve should be furnished where the load varies.
2. Motors not geared may be specified merely with hp. rating.

C. SPEED AT OUTPUT SHAFT.
1. Specify speed in r.p.m. and constancy desired.....
2. If rheostat or potentiometer control is to be used, speed range should be specified ..... to .....

D. DIRECTION OF ROTATION. Specify, looking at end of output shaft.
1. Clockwise or counter-clockwise .....
2. Reversible ..... If so, instantaneously .....

E. DUTY CYCLE. Important because of heat and hence weight.
1. Maximum time on ..... and minimum time off .....
2. Duration of any fluctuation in load .....
3. Frequency of load cycles .....

F. AMBIENT TEMPERATURE RANGE. Important for bearing on power and weight.
1. Range of temperature in which motor must operate ..... to .....
2. Is it near exhaust manifold, etc. .....

G. ALLOWABLE MAXIMUM WEIGHTS. Important limiting factor. .....

H. SPACE LIMITATIONS .....
1. It is best to supply a sketch showing envelope available for motor and associated gearing, limit switches, brake, and other items.

I. MOUNTING REQUIREMENTS.
1. Furnish a sketch showing relation between mounting holes, output shaft and connector.

J. SHAFT DIMENSIONS.
1. Length ..... Dia. ..... Keyway ..... Flat ..... Slot ..... Spline ..... Pinion .....
2. Advisable to furnish a sketch.

K. TYPE OF ELECTRICAL CONNECTION.
1. AN connector or other special type .....
2. Leads, type ....., length .....
3. Terminal lugs .....
4. Is system a one-wire or two-wire system .....

L. SPECIAL REQUIREMENTS.
1. Thermal overload protection .....
2. Magnetic clutch and/or brake .....
3. Limit switches .....
4. Governor control .....
5. Position indicator .....
6. Explosion proofing .....
7. Other .....

or minus one percent. The rule of thumb limit on current is 1.5 amp.; higher currents cause rapid burning and pitting of the contacts. A proper selection of values for the resistor and condenser shunted across the contacts is essential in reducing arcing to a minimum.

MANUAL OPERATION is usually provided on devices where it is advisable to have a positive control in the event of motor failure. For instance, a shaft and crank are provided for lowering the landing gear so that the pilot will not be forced into a crash landing should one small motor fail. Fear of motor failure is predicated upon the chance of an enemy bullet finding the motor, not upon the motor itself being defective. The shaft for manual operation is usually connected in between the gearing and the output shaft so that the operator will not have to turn the gears. The mechanical advantage of some of the higher ratios is so great that it is impossible to turn them backward from the output shaft.

AUTOMATIC CONTROL through thermostats, pressure switches, float switches and similar devices is being introduced to eliminate the necessity of the pilot having to operate accessories even by push button control. Some motor manufacturers are prepared to issue this equipment, but its use is far from widespread because such operation imposes many new and severe conditions on the motors. With automatic control, the operation of the motor is likely to be far more frequent than with control by the operator. But apparently this is the next step and motors will be developed inevitably to meet the severities imposed.

ACTUATING EQUIPMENT. Here the trend is toward furnishing a complete power package consisting of a motor, gearing, limit switches and screw jack or bell crank. This permits the aircraft manufacturer to install, without further assembly, the complete drive mechanism or actuating device to the driven unit. The advantage, aside from the reduction of assembly time at the aircraft manufacturer's plant, is to place complete responsibility for the drive mechanism squarely on the shoulders of one manufacturer.

Ordering Fractional Horsepower Motors

Motor manufacturers cannot design a motor properly without complete data covering the customer's particular requirements. This is true even in peacetime when the customer might be the manufacturer of a kitchen mixer. It is a thousand times more important when the customer is a manufacturer of aircraft in wartime, when every day's delay in getting into production on a motor order is of incalculable gravity. Many factors affecting motor power, size and weight are not appreciated by the purchaser, but are of the utmost importance in designing the most efficient and lightest unit. If time is important these factors should be established in the first conversation so that intelligent designing and testing can proceed without delay. All pertinent specifications should be clarified at the earliest possible moment, because it is impossible to plan any motor job constructively until they are established.

It follows that the purchaser should become as familiar as possible with motor characteristics and performance features so that he can describe his own requirements completely and coherently. Manufacturers are anxious to have their customers proceed on this basis. A completely filled out specification list is the first step in discussing plans for a new motor. A check list as given in Table I contains all the specifications and engineering data required by a manufacturer to develop a preliminary aircraft motor design.

Hydraulic CONTROLS

for PRESENT and POST-WAR PRODUCTS

An editorial resume of the

basic characteristics and functions of hydraulic units, emphasizing

new developments and typical applications.

★ HYDRAULIC CONTROL SYSTEMS

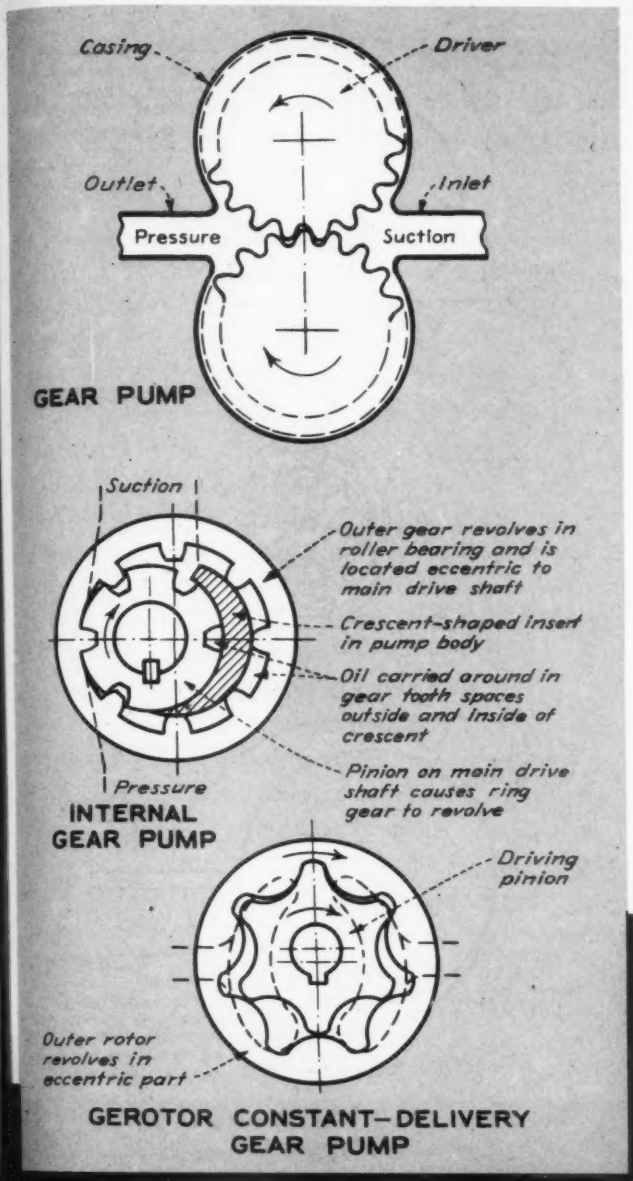
● ALL HYDRAULIC SYSTEMS consist essentially of a *pumping unit* which delivers fluid through piping and suitable valves to a *hydraulic motor* or *cylinder*. Valves, available in a great variety of types, are selected to obtain specialized functions or cycles of operation. Through proper selection of pump, valves and motor, a wide variety of motions, sequences of motion, or cycles of operation with respect to time, force and velocity, can be obtained.

PUMPING UNITS—Fundamentally classified into two groups: Constant delivery at constant speed; variable delivery at constant speed.

VALVES—Usually grouped into three main divisions: *Pressure control*—to limit maximum pressure, operate circuits in sequence, control pump pressure; *volume control*—to govern rate of fluid flowing to various parts of the circuit; *directional control* — operated manually, mechanically, electrically, pneumatically, or hydraulically to direct flow of fluid to various parts of the circuit or circuits. Many special types of valves have been developed.

CYLINDERS, MOTORS and TRANSMISSIONS—Convert hydraulic energy to mechanical energy. Motors fall into three classes: Gear, vane and piston types. Transmissions are essentially pump-motor units.

● Hydraulic controls, because of their versatility, have been widely adapted to metal-working machinery, aircraft and transportation equipment, industrial machinery of all types, processing, construction and agricultural equipment. After desired motions, horsepower requirements and other operating characteristics have been determined, selection of proper units and design of specific circuits should be done in cooperation with manufacturers or specialists, to insure circuit efficiency.



HYDRAULIC PUMPS

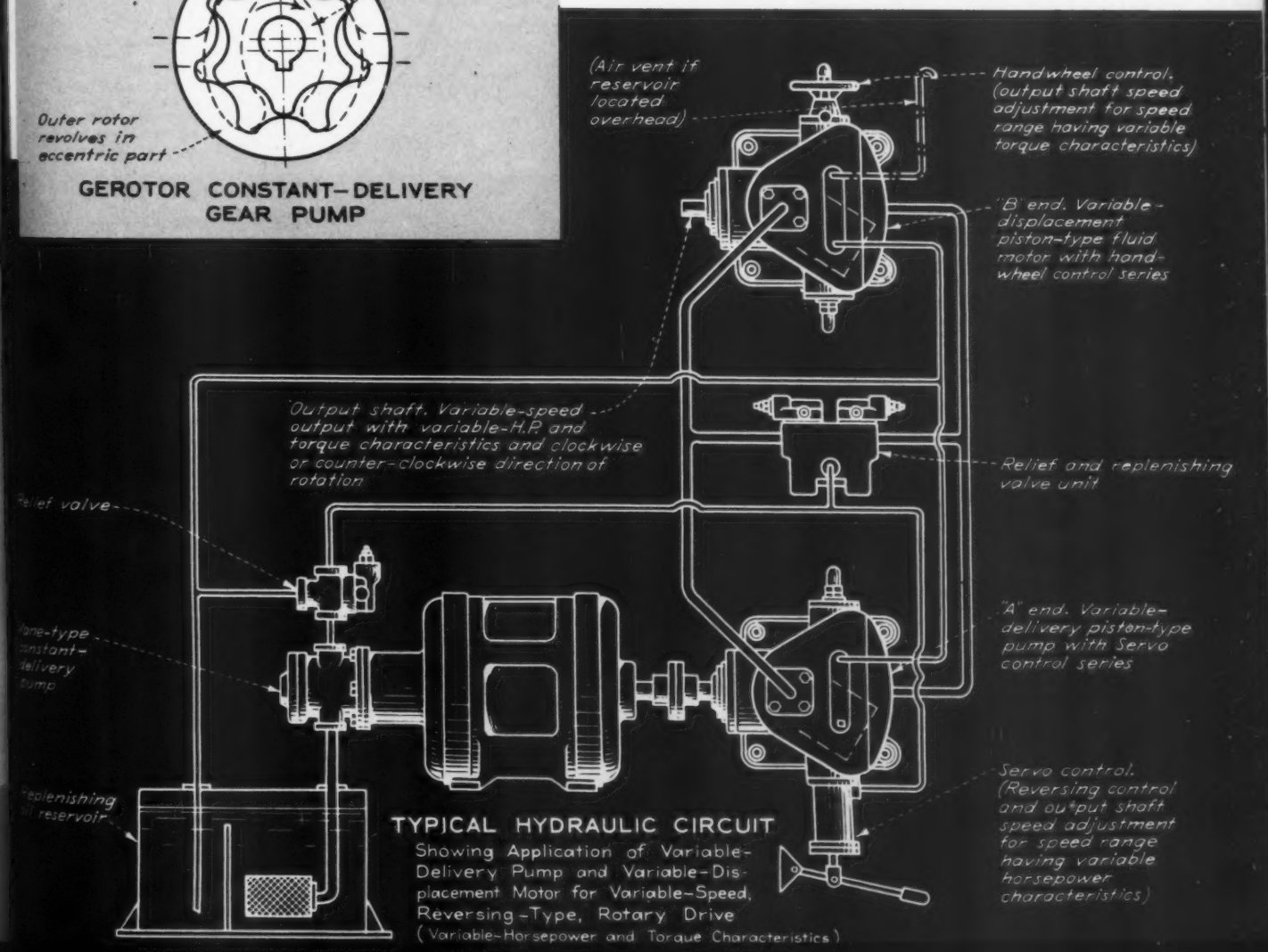
GEAR PUMPS

Type — Constant Delivery

Operation — As gears revolve, oil is trapped in pockets formed between pump case and teeth of gears, and is carried from intake to discharge port of the pump. Meshing of gears prevents return of oil to suction side of pump. Any leakage between gear teeth or between gear teeth and casing decreases volumetric efficiency correspondingly. Hence the pumps must be made with extremely close fits. Gears may be straight, helical, herringbone, or special forms for high pressures. Helically-cut gears run quieter. Any wear caused by dirt or abrasive in the oil lines will reduce effective output.

Some manufacturers provide "balanced" gear pumps in which high pressure and low pressure ports are located so that gears are not subject to unbalanced hydraulic loads.

Gear pumps are lowest in cost but are most susceptible to leakage.


(Air vent if reservoir located overhead)
Handwheel control. (output shaft speed adjustment for speed range having variable torque characteristics)
"B" end. Variable-displacement piston-type fluid motor with hand-wheel control series
Output shaft. Variable-speed output with variable-H.P. and torque characteristics and clockwise or counter-clockwise direction of rotation
Relief and replenishing valve unit
Relief valve
Vane-type constant-delivery pump
"A" end. Variable-delivery piston-type pump with Servo control series
Replenishing oil reservoir
Servo control. (Reversing control and output shaft speed adjustment for speed range having variable horsepower characteristics)
TYPICAL HYDRAULIC CIRCUIT
Showing Application of Variable-Delivery Pump and Variable-Displacement Motor for Variable-Speed, Reversing-Type, Rotary Drive
(Variable-Horsepower and Torque Characteristics)

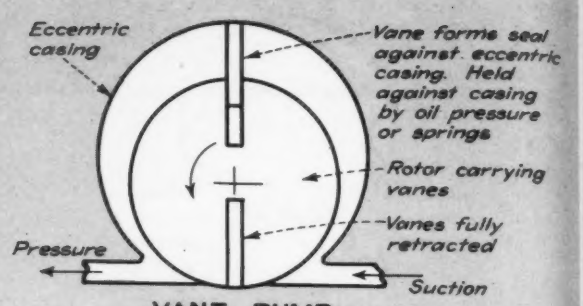
HYDRAULIC PUMPS

VANE PUMPS

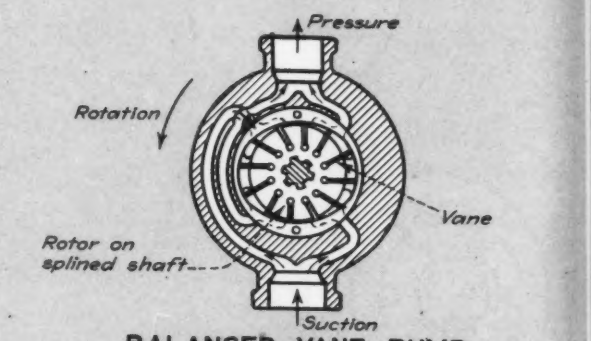
Type — Constant Delivery or Variable Delivery

Operation — Rotating hub carries vanes which are free to slide in or out, and which form a seal against eccentric casing. Positive contact of vanes with casing is assured by either spring action or high pressure oil behind vanes. As hub revolves, vanes form chambers to trap oil; as hub continues to rotate, these chambers gradually decrease in volume forcing oil out through discharge port. Because of close fits between vane, hub and casing, high pressures can be developed. Vane-type pumps do not lose their volumetric efficiency through wear as rapidly as do the gear-type pumps. The only points of wear which might affect volumetric efficiency are the tips of the vanes. However, by virtue of the manner in which the vanes are mounted in the hub, tip wear is continuously compensated by the vanes moving outward radially. Thus a seal is maintained between the vane tip and casing throughout the life of the pump.

Variable-discharge vane pumps are obtainable. Such pumps are constructed so that the eccentricity of the outer ring is adjustable.


Eccentric casing
Vane forms seal against eccentric casing. Held against casing by oil pressure or springs
Rotor carrying vanes
Vanes fully retracted
Pressure
Suction

VANE PUMP



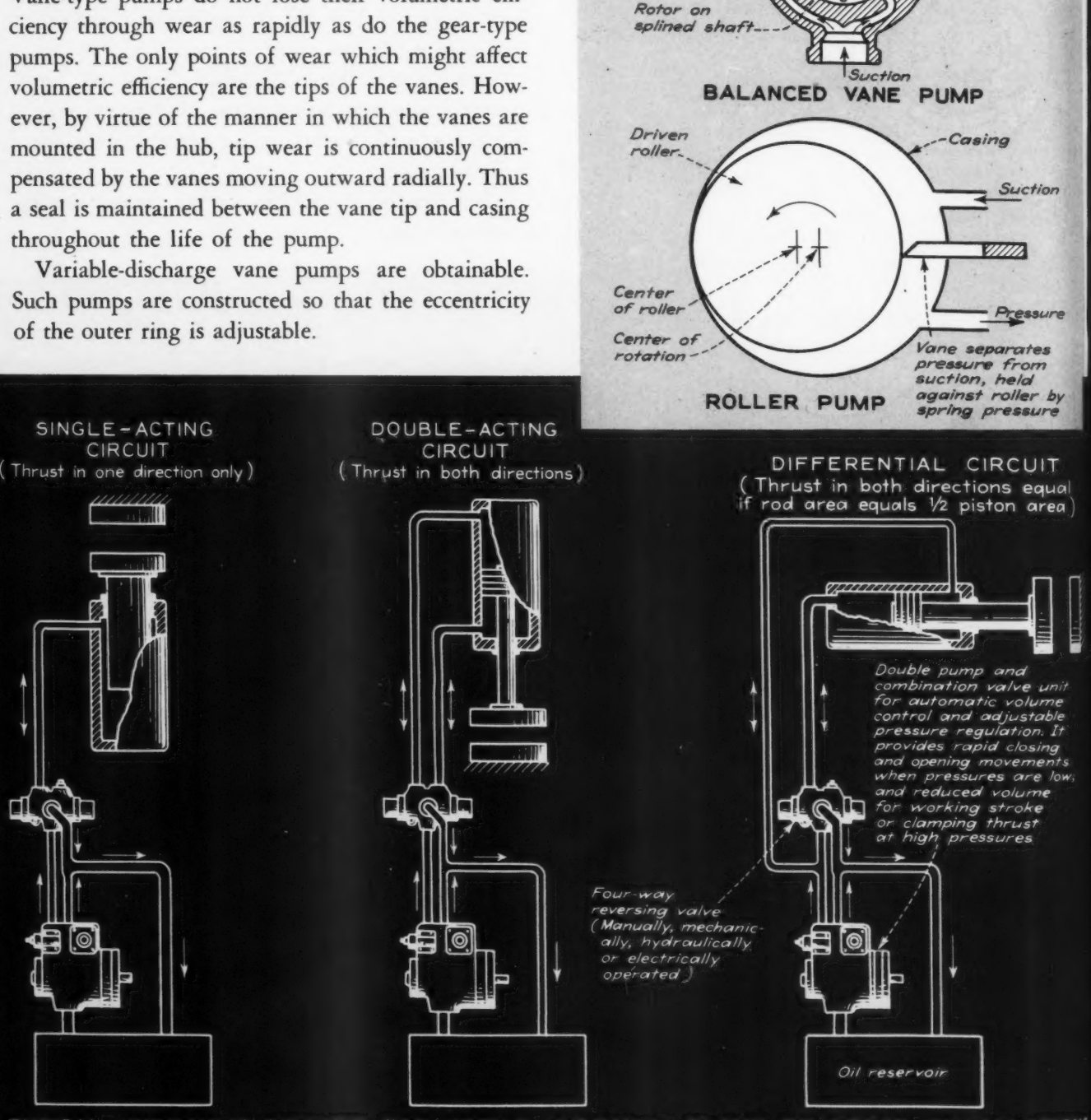
BALANCED VANE PUMP

ROLLER PUMP

SINGLE-ACTING CIRCUIT
(Thrust in one direction only)

DOUBLE-ACTING CIRCUIT
(Thrust in both directions)

DIFFERENTIAL CIRCUIT
(Thrust in both directions equal if rod area equals ½ piston area)


Double pump and combination valve unit for automatic volume control and adjustable pressure regulation. It provides rapid closing and opening movements when pressures are low, and reduced volume for working stroke or clamping thrust at high pressures
Four-way reversing valve (Manually, mechanically, hydraulically or electrically operated)
Oil reservoir

TYPICAL HYDRAULIC CIRCUITS FOR SIMPLE HYDRAULIC CLAMP OR PRESS INSTALLATIONS

PISTON PUMPS

Type — Constant Delivery or Variable Delivery

These pumps are adaptable to applications in which variable-speed control is important. Output adjustment can be manual or automatic.

Operation — AXIAL-PISTON types consist of a driving plate, and cylinder-block assembly. Pistons are driven through connecting rods attached to driving plate with ball and socket joints. Angle determines stroke of pistons. If this angle is fixed, the pump is constant delivery; if adjustable by some external means, pump becomes variable delivery type. As driving plate and cylinders revolve, pistons move in and out, since connecting rod lengths remain constant.

Some types drive pistons by use of a wobbler. Adjustment of wobbler angle varies delivery of pump. Positive return of pistons can be obtained by fixing connecting rods in wobbler plate, or by spring loading, or by admitting high pressure oil behind pistons.

These pumps can deliver oil at high pressures.

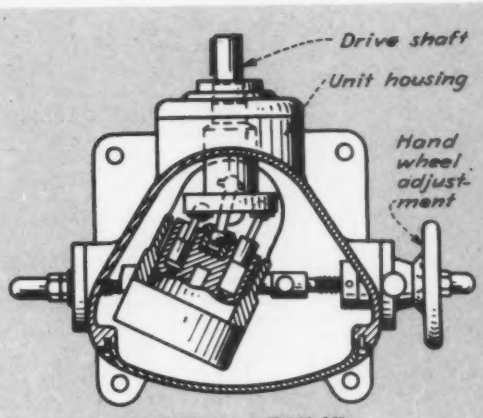
RADIAL-PISTON types consist basically of a rotating cylinder block containing radial cylinders and with pistons which are in sliding contact with an outer casing. Volume of oil pumped is controlled by eccentricity of the outer casing with respect to the rotating cylinder block. When casing and rotating cylinder are concentric, no oil is pumped. As casing is shifted off center, volume pumped increases. Shifting of casing to opposite eccentricity reverses flow. Thus output is closely controlled from zero to maximum in either direction.

Numerous designs of this type are available, some utilizing free-rolling pistons, others tee-shaped crossheads as the connecting link between pistons and outer casing, others have tee-shaped plungers fitting into guides bearing on the outer casing, or pistons fitted with crosshead rollers that bear against the outer ring.

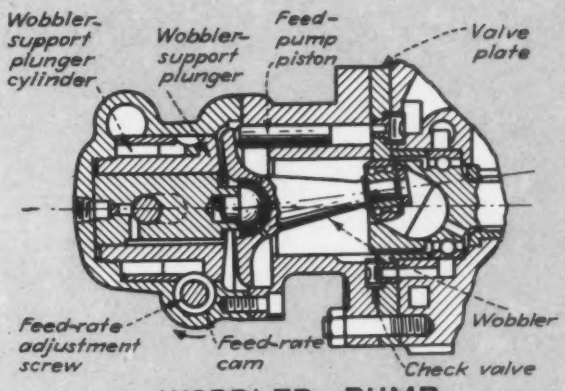
ANOTHER TYPE of piston pump for high pressures consists of several pistons and cylinders located radially with the drive shaft on which an eccentric bearing is fitted. Back pressure maintained on pump inlet line by a gear pump causes the piston to follow the finger. In certain models, pump output is varied by changing eccentricity of ball bearing race, or by arresting finger motion through use of special cams.

★

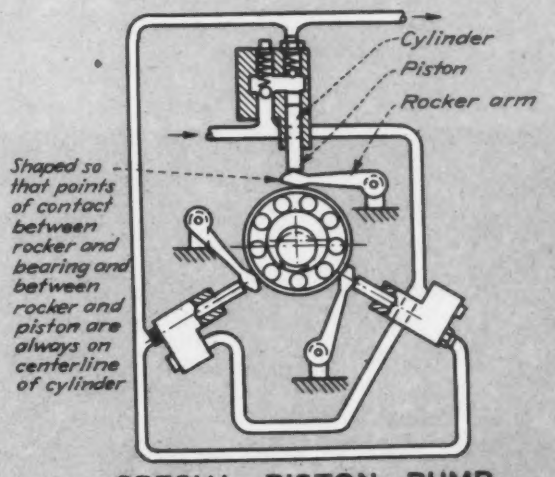
● All the above types of variable delivery pumps can be fitted with controls that automatically lower pump output as circuit pressure builds up. This is done by reducing angular displacement of shafts or wobbler in some types, or by changing rotor eccentricity in other types. At minimum output pump supplies only enough oil to compensate system losses.



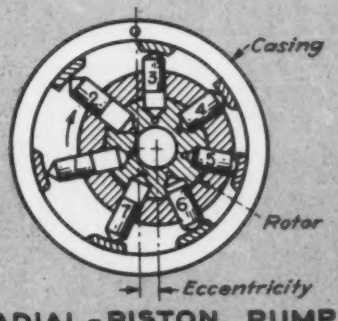
PISTON PUMP



WOBBLER PUMP

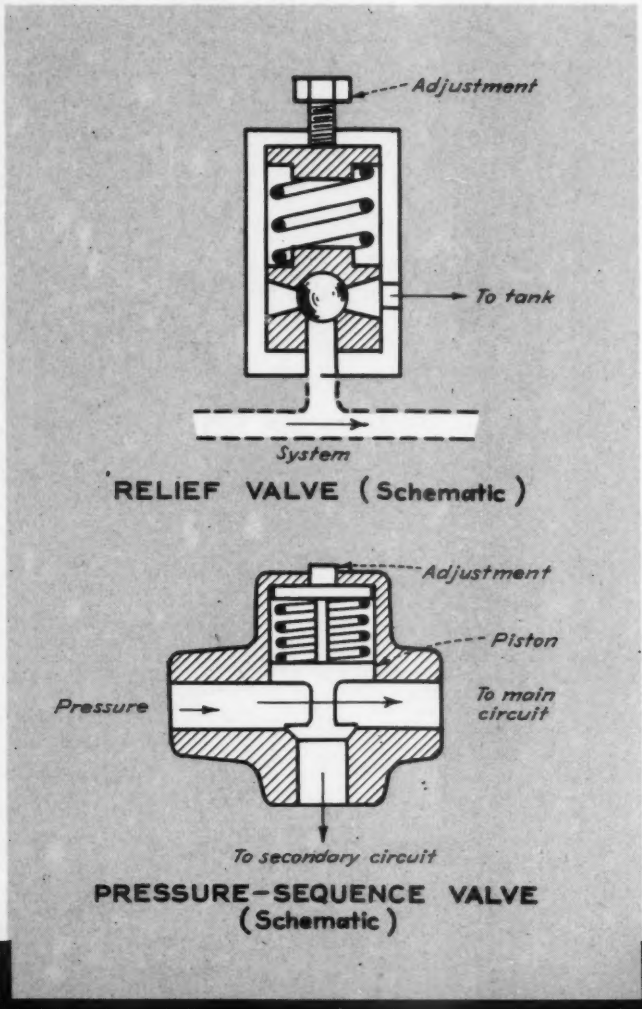

Cylinder
Piston
Rocker arm
Shaped so that points of contact between rocker and bearing and between rocker and piston are always on centerline of cylinder

SPECIAL PISTON PUMP



RADIAL-PISTON PUMP

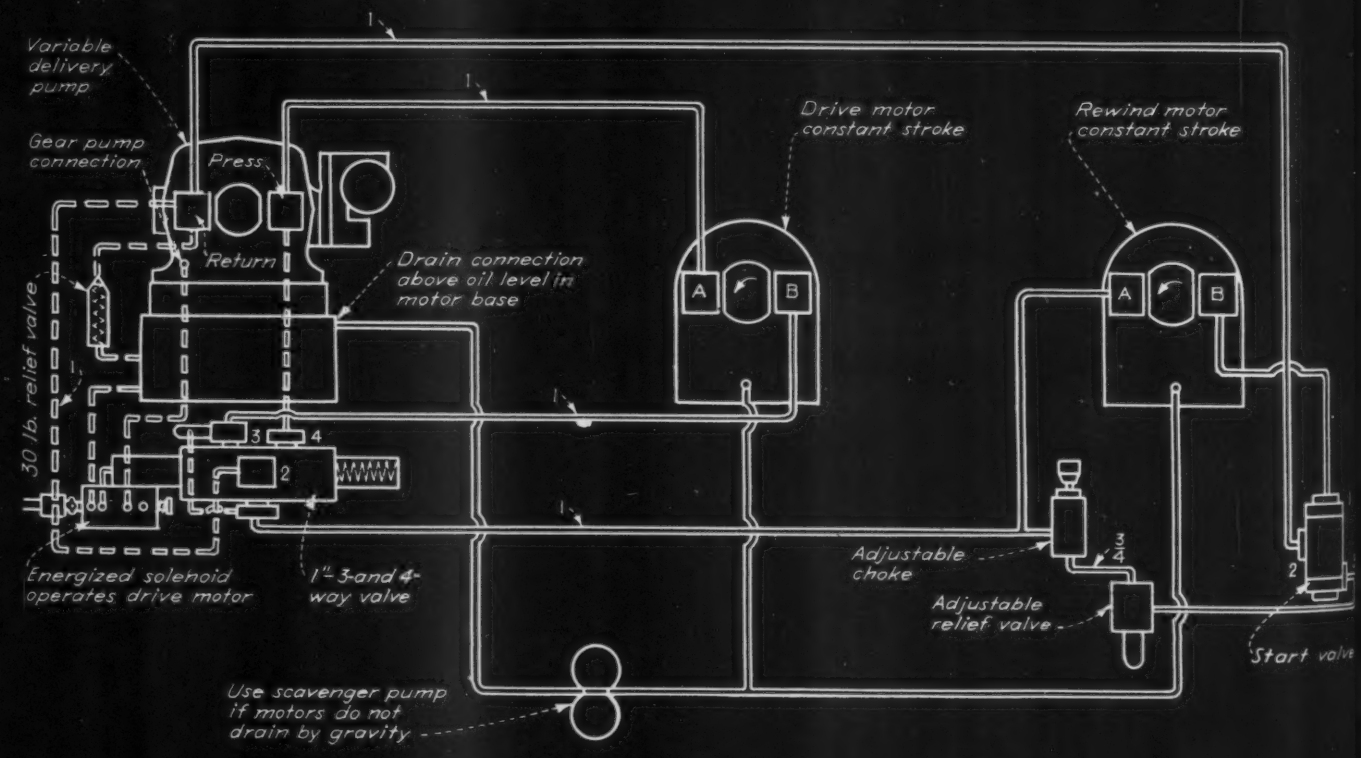
PRESSURE-CONTROL VALVES



● Operated by pressure differentials. Can be used to limit maximum pressure, to control sequence of operation by governing pressure to branch circuits; to return fluid without resistance to reservoir when system pressure builds up; to reduce pressure in system lines, and to perform many other operations where pressure can be used to open or close valves.

RELIEF VALVE—Used to limit pressure in a circuit to a desired maximum. It is adjustable and can be remotely controlled if necessary. High pressure oil is discharged through valve to reservoir. Energy of high pressure fluid is converted to heat when being relieved, hence valve should be used only as safety valve and not as an unloading valve if large discharge volume is to be considered.

SEQUENCE VALVE—An adjustable pressure-operated valve can be used to control sequence of flow to various secondary circuits. Valve is connected in line, allows free flow to main circuit until pressure builds up to desired point. The valve opens and supplies oil under pressure to secondary circuit while still maintaining flow into main circuit, valve simply acting as a tee under these conditions. Check valves are sometimes incorporated in the design to permit free reverse flow.

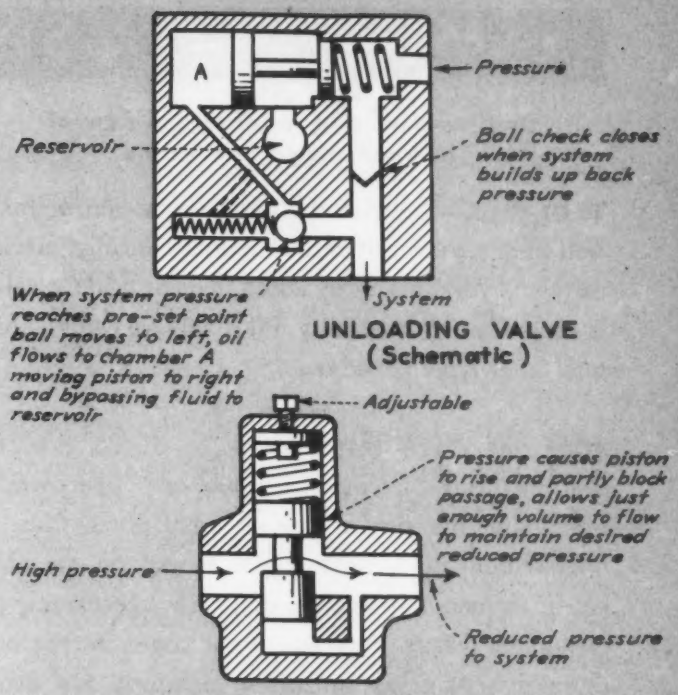


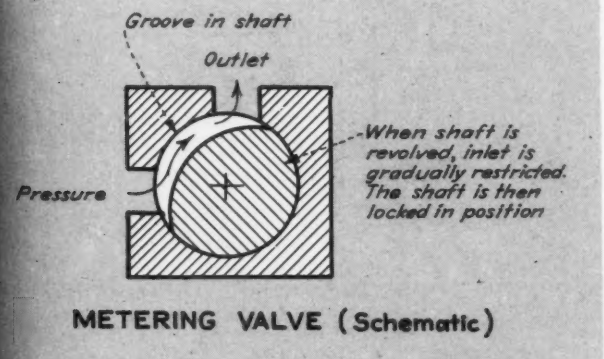
PRINTING PRESS DRIVE WITH REWINDER

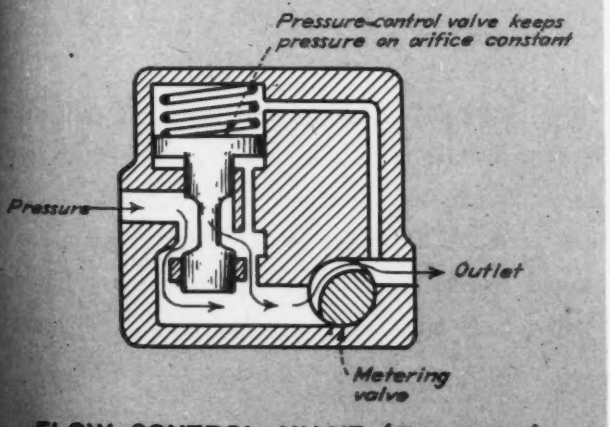
UNLOADING VALVE—Used to return oil to reservoir without flow resistance when system pressure builds up to pre-set maximum. For instance, where a constant delivery pump is supplying oil to the circuit and the cylinders have completed their stroke, pressure will build up in the system. In such cases, an unloading valve will open and bypass the oil back to the reservoir. No heat need be dissipated.

PRESSURE-REDUCING VALVE—Certain parts of hydraulic control circuits may require reduced pressures for operation. Pressure reduction is accomplished through use of an adjustable reducing valve which allows just enough flow to maintain desired reduction in secondary circuit while higher pressure in supply system may fluctuate or stay constant.

PRESSURE SWITCH—Used where the flow of a hydraulic circuit is to be controlled electrically through the pressure of the same circuit or the pressure of a branch circuit. Pressure causes the switch to operate a solenoid or a safety device, which in turn can be used to change direction of fluid flow or to stop the pump. These can be fitted with needle valves for adjustment of reset speed.


A
Pressure
Reservoir
Ball check closes when system builds up back pressure
When system pressure reaches pre-set point ball moves to left, oil flows to chamber A moving piston to right and bypassing fluid to reservoir
System
UNLOADING VALVE (Schematic)
Adjustable
Pressure causes piston to rise and partly block passage, allows just enough volume to flow to maintain desired reduced pressure
High pressure
Reduced pressure to system
REDUCING VALVE (Schematic)
Piston
Roller
Piston
Adjusting nut
Pressure
Switch
Arm
PRESSURE SWITCH (Schematic)


Groove in shaft
Outlet
When shaft is revolved, inlet is gradually restricted. The shaft is then locked in position
Pressure
METERING VALVE (Schematic)



VOLUME-CONTROL VALVES

Fitted with means for governing rate of fluid flow to particular circuits

METERING VALVE—Restricts or limits the flow of hydraulic fluid to be delivered to or discharged from an operating mechanism. Sometimes used to cushion pistons at end of stroke or to delay action of hydraulically-operated valves.

FLOW-CONTROL VALVE—For hydraulic circuits where rate of liquid flow in a certain direction must be controlled. Can govern piston movement so that rate of piston travel will be constant regardless of fluid pressure, oil viscosity or magnitude of variable load. Can be used to prevent tools from jumping ahead when breaking through work. Meters in, meters out or bleeds off fluid in a circuit.

DIRECTIONAL-CONTROL VALVES

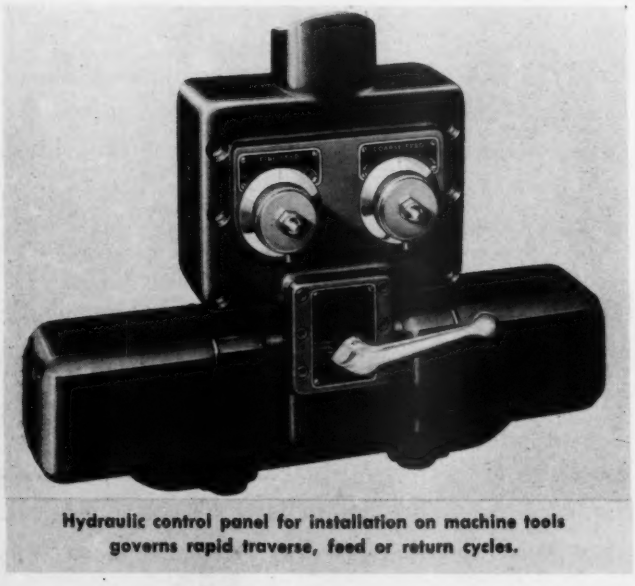
Used to start, stop, or direct the flow of hydraulic liquid in a circuit

PILOT VALVE—Controls the position, motion or function of a second valve. Can be mechanically, electrically or hydraulically operated. The secondary valve is controlled hydraulically. Pilot valving can be built into other types of valves.

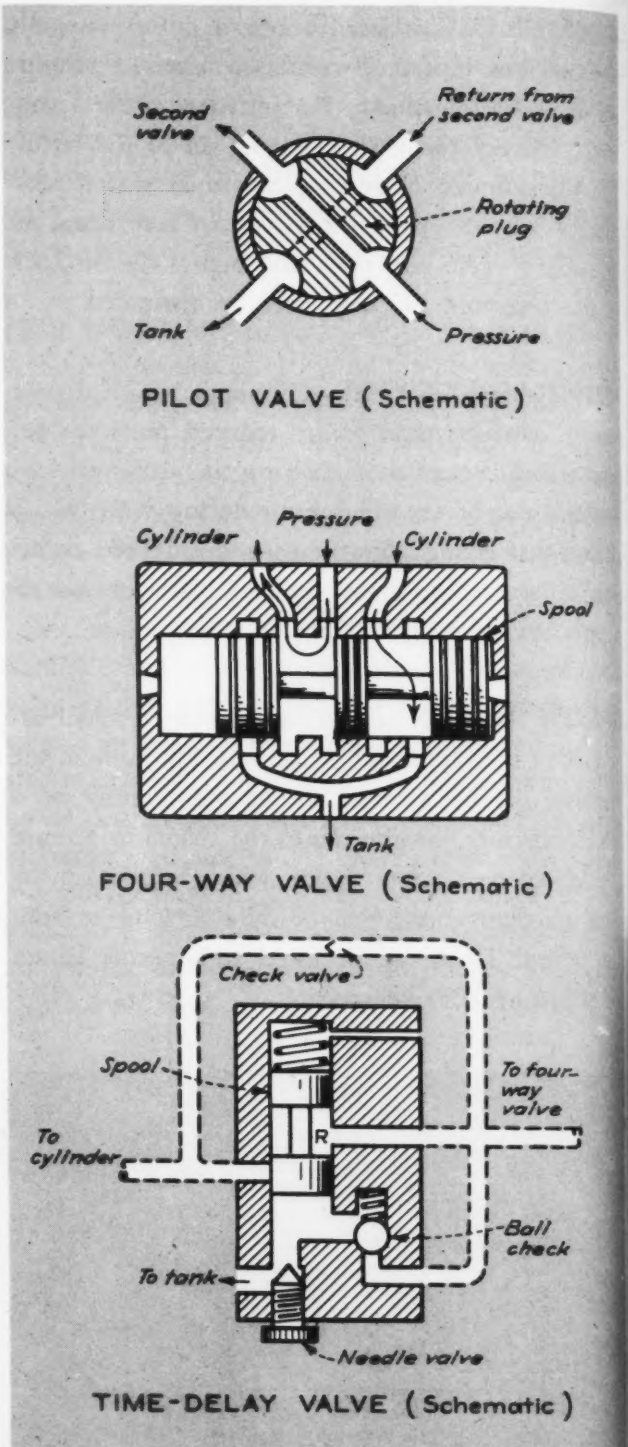
FOUR-WAY VALVE—Starts, stops, or directs flow of fluid by means of a movable spool or poppets which open, shut or obstruct one or more ports. Can be operated by fluid pressure differential on movable spool, or manually, electrically, or by mechanical or pneumatic means. Four-way is the common type but these direction valves can be obtained for two-, three-, four-, five-, and six-way directional control.

TIME-DELAY VALVE—Used when change of liquid flow from one circuit to another must occur after a specified time interval. Design generally incorporates a spool and a needle valve for flow adjustment. Liquid from four-way valve flows past ball check, maintains spool in closed position. At same time, liquid flows past check valve and does work in cylinder. When four-way valve is reversed, fluid bleeds out past needle valve from chamber below spool, since ball check closes, and spool drops, permitting fluid return from cylinder to flow through chamber R back to four-way valve.

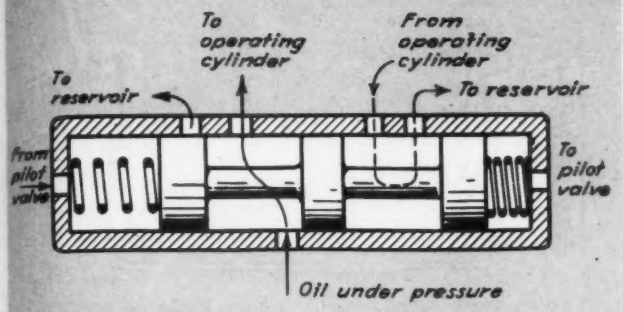
Vickers, Inc.



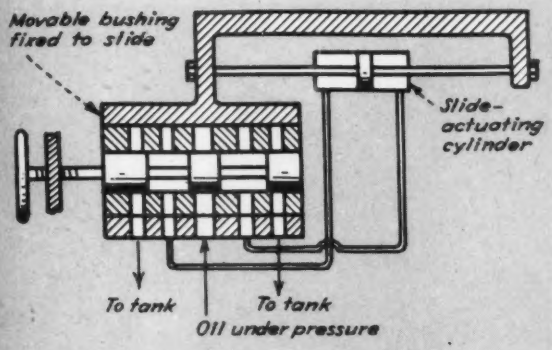
Hydraulic control panel for installation on machine tools governs rapid traverse, feed or return cycles.



CONTROL PANELS—Combination units for controlling rapid traverse; feed and return cycles. Units incorporate directional-control spools, feed-control valves and pressure compensator. Operation can be controlled manually or by pilot pressure and by cam actuation. In one design, spools are solenoid-actuated and returned by spring action.



REVERSING VALVE (Schematic)



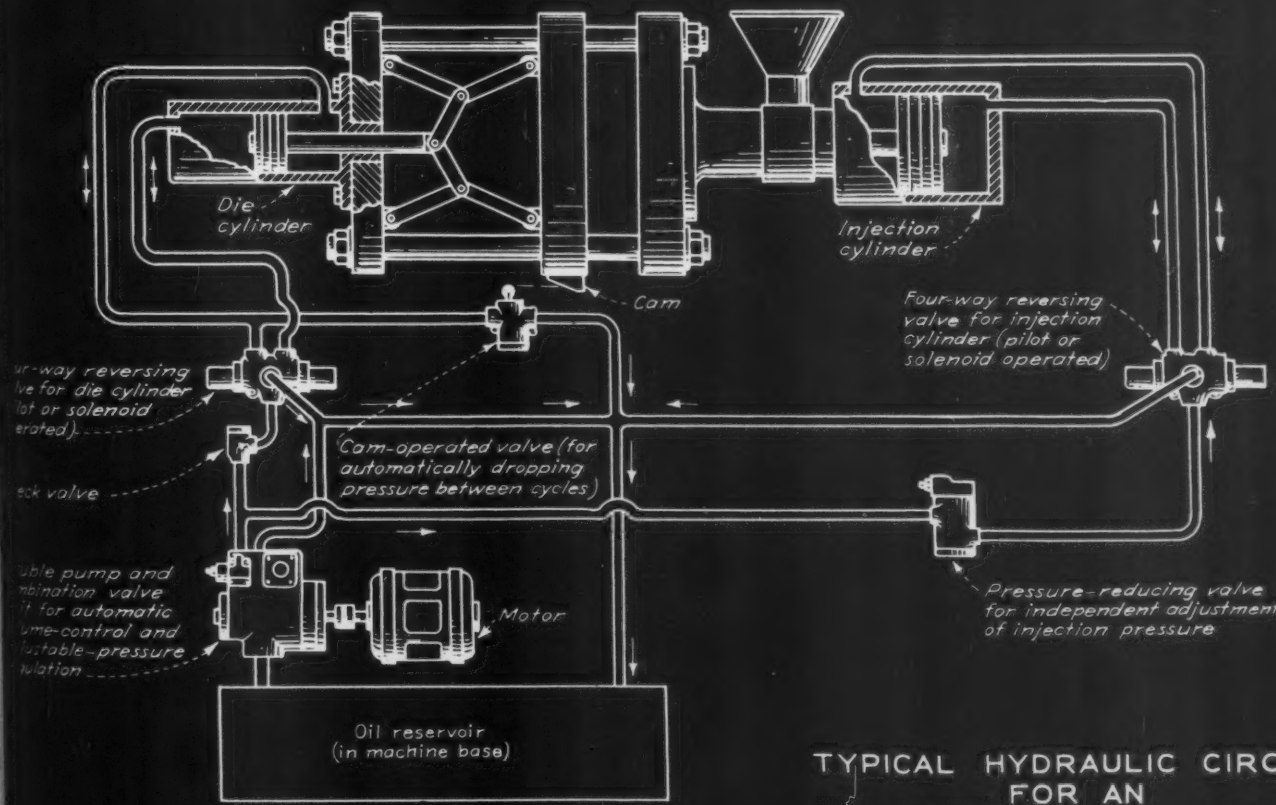
SERVO VALVE (Schematic)

SPECIAL VALVES

REVERSING VALVE—Valve directs fluid flow in and out of either end of an operating cylinder. A separate pilot valve controls fluid pressure to the reversing valve. Reversing valve spool floats between springs, and pilot valve action causes movement of spool in either direction.

SERVO VALVE—Used to move large masses with minimum of operator effort. Basically similar to hydraulic directional control valves previously described, except that both spool and bushing move. The bushing is connected to the moving slide so that when movement of the slide occurs, the bushing moves to close off the valve. A small axial movement of the screw produces small movement of the slide. Only load on screw is that necessary to move valve in its bushing.

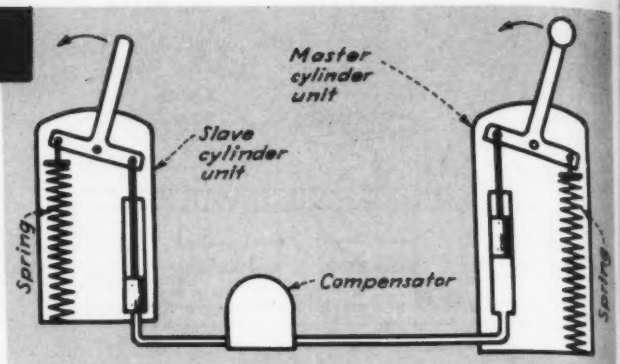
CHECK VALVE—Used to permit hydraulic fluid flow in one direction only.


Die cylinder
Injection cylinder
Cam
Four-way reversing valve for injection cylinder (pilot or solenoid operated)
Cam-operated valve (for automatically dropping pressure between cycles)
Motor
Pressure-reducing valve for independent adjustment of injection pressure
Oil reservoir (in machine base)

TYPICAL HYDRAULIC CIRCUIT FOR AN INJECTION MOLDING MACHINE

REMOTE CONTROL SYSTEMS

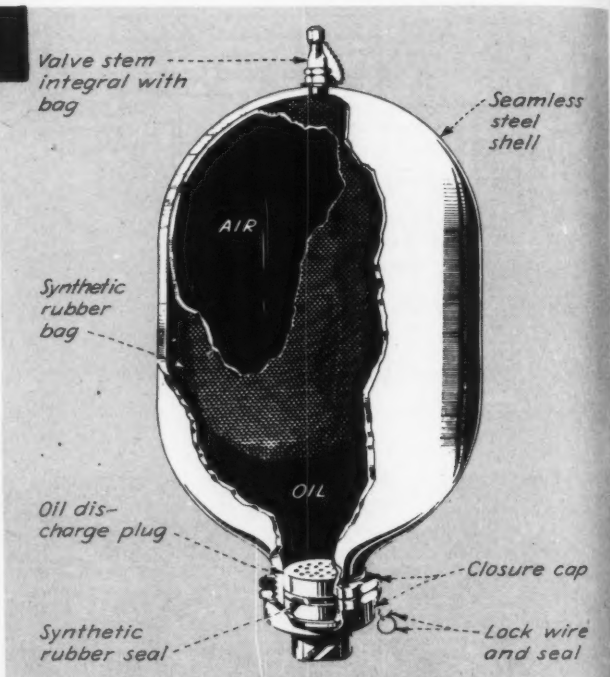
● Basically utilize a master cylinder and a slave cylinder. Receiver lever moves through arc equal to that of transmitter handle. To prevent operation inaccuracies caused by leakage or temperature changes some compensating means is included in the design. These units can be applied to aircraft engine control, marine control, railroad equipment.



REMOTE CONTROL UNIT (Schematic)

ACCUMULATORS

● Containers used for storing hydraulic fluid under pressure, where the machine requires for a short time a greater volume of fluid than the pump can supply. Thus pump size can be governed by average circuit demand, and accumulator will store fluid for peak demand. Accumulators utilize a cylinder chamber and piston, chamber and rubber diaphragm, or chamber and bellows, or gas-filled chambers. They are generally placed in the line between pump and selector valves.



ACCUMULATOR

Logansport Machine

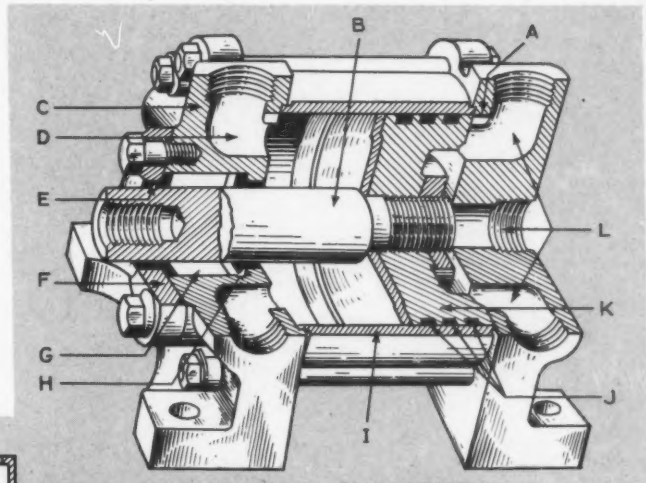
Solenoid-operated hydraulic control valve for use in electrically controlled hydraulic circuits.

HYDRAULIC CYLINDERS, MOTORS AND TRANSMISSIONS

For converting hydraulic energy to mechanical energy

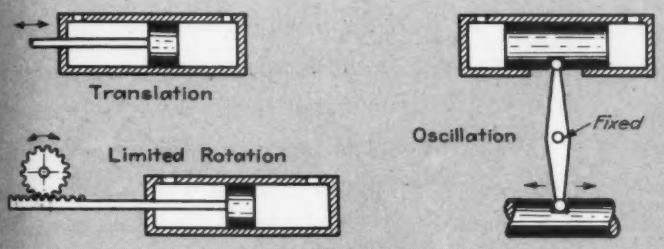
CYLINDERS — Simplest and most widely used hydraulic mechanism. Converts hydraulic energy to energy of translation, or energy of rotation where limited angle of motion is desired.

MOTORS are of gear type, wobbler type, vane type or piston type and are basically similar to these same types of hydraulic pumps. Motors are available in fixed displacement and variable displacement types. See pages 3 to 5 for descriptions of pump construction.



HYDRAULIC CYLINDERS

A. Air vents to eliminate air pockets.
B. Piston rod alloy steel.
C. Covers chrome nickel cast iron.
D. Large outlet and inlet for rapid action.
E. Bronze packing gland.
F. Steel packing gland cap.
G. Hydraulic type seal ring packing.
H. Bronze piston rod guide bushing.
I. Seamless steel tube bored and honed to size.
J. Automotive type piston ring seal.
K. Piston chrome nickel cast iron.
L. Multiple pipe connections for convenient installation.

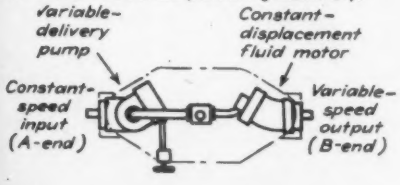


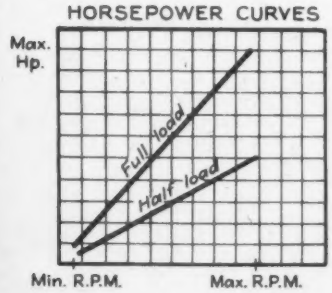
USE OF HYDRAULIC CYLINDERS (Schematic)

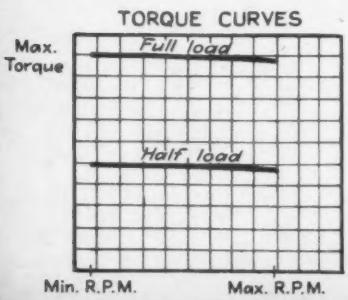
TYPICAL PERFORMANCE CURVES FOR VARIABLE SPEED HYDRAULIC TRANSMISSIONS

VARIABLE HORSEPOWER TYPE

For installations requiring constant torque type power. Characteristics such as conveyors, machine tool feeds, stokers and processing machinery.

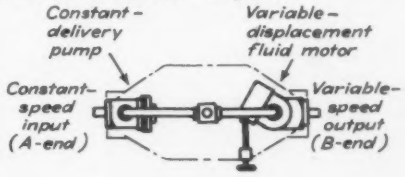


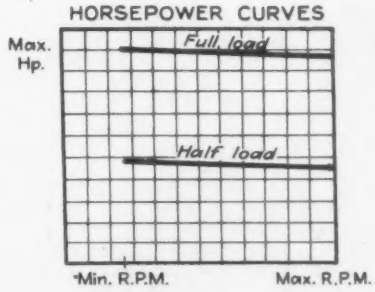


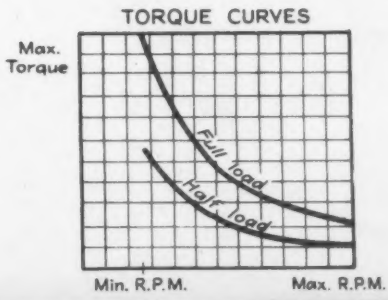


VARIABLE TORQUE TYPE

For installations requiring constant horsepower type power. Characteristics such as coiling, rewind, planer and machine tool cutting drives.

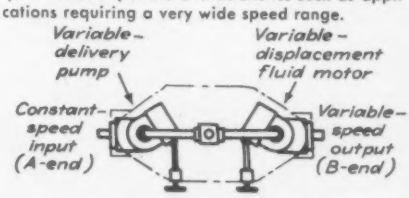


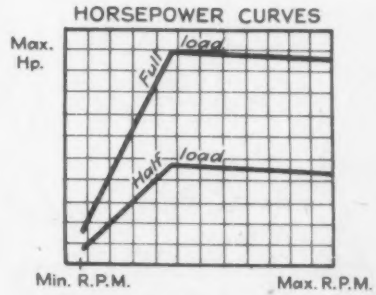


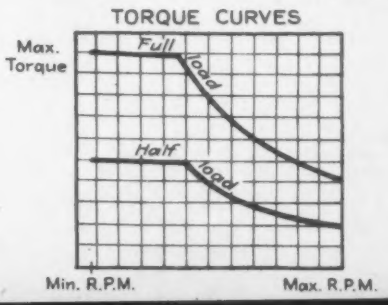


VARIABLE TORQUE & H.P. TYPE

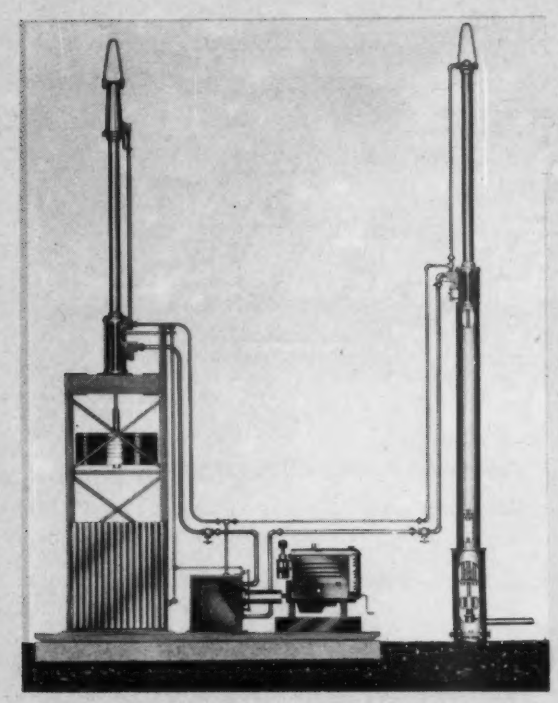
For installations requiring any combination of torque and horsepower. Characteristics such as applications requiring a very wide speed range.







RECENT DEVELOPMENTS IN HYDRAULIC EQUIPMENT

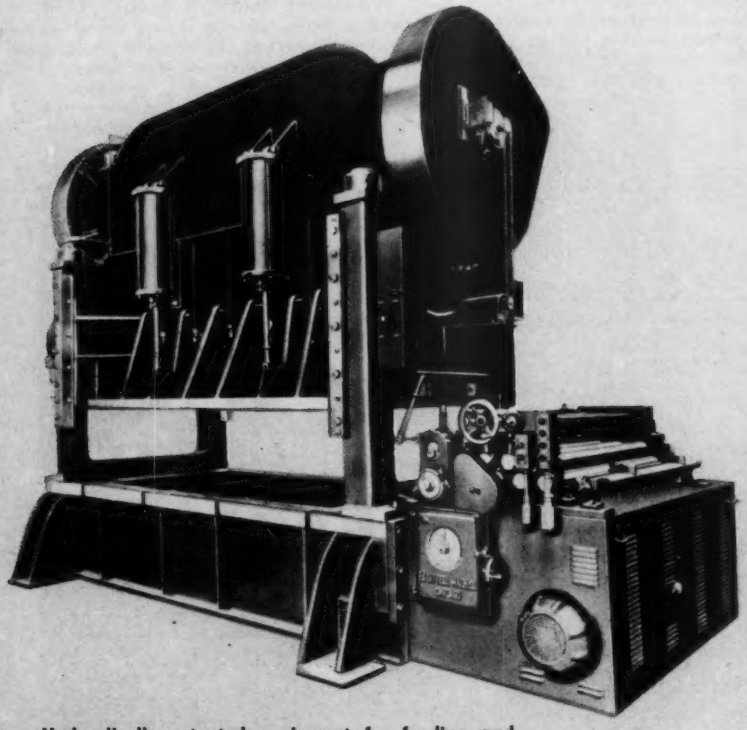


Oil well pumping unit. Design eliminates rod breakage. With this unit, the rods are raised and lowered by a piston operating in a hydraulic cylinder mounted over the well. Vickers equipment provides long smooth strokes of constant speed, controlled easy acceleration and deceleration, shockless reversal.

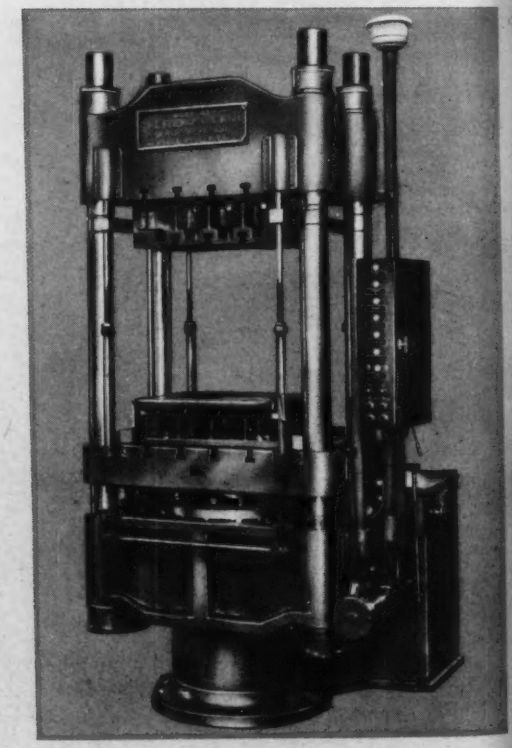
PISTON-TYPE PUMPS are now available in small sizes with high output. One manufacturer has developed a constant delivery pump of this type, which operates at 3,600 r.p.m. delivers 5-10 hp, and weighs less than 3 lb. It is being used in certain aircraft applications.

Another pump under development incorporates a wobbler drive and a unique unloading feature built into the pump drive.

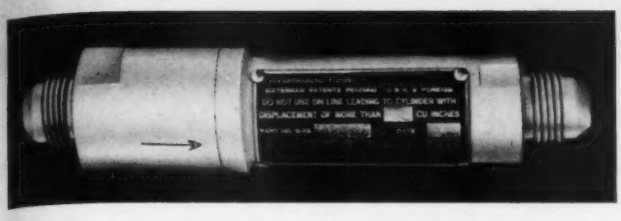
One special design utilizes back pressure to control wobbler plate angularity and thus reduce output as system pressure builds up. Still another design of axial-type piston pump includes provision for automatically changing shaft angularity as pressure builds up, thus reducing pump output. Made up of electric motor, pump and transmission, requires no piping except to reservoir. These units are extremely compact in design, light in weight.



Hydraulically actuated equipment for feeding and straightening steel from coiled strips. Hydraulic variable speed transmission supplies rapid traverse or slow forward feed. Operation of solenoid valves effects rapid-traverse reverse or stops the feed.

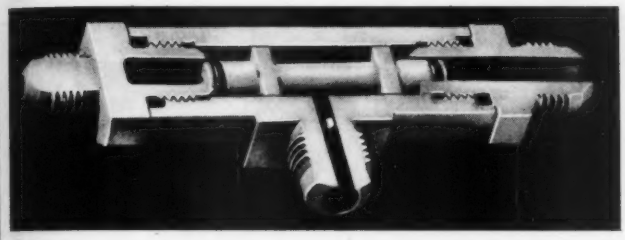


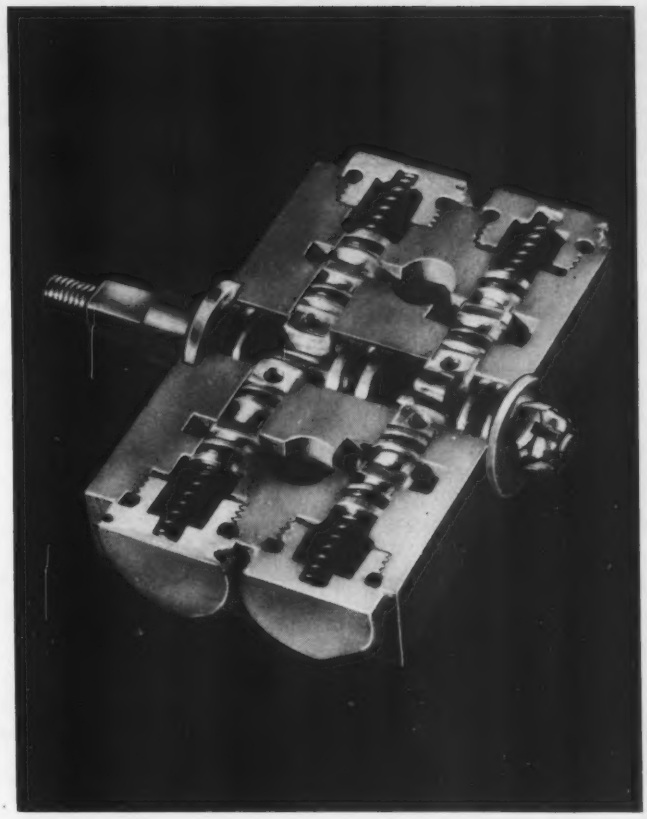
High-speed plastic molding press in which hydraulic equipment supplies completely automatic timing control. Control is instantly adjustable.



HYDRAULIC FUSE — A quantity-measuring valve that acts as a safety shut-off when a hydraulic line ruptures. Remainder of system can still operate after valve isolates broken line. Operates regardless of oil viscosity or rate of flow. Capacities range from 10 to 40 cu. in. in size.

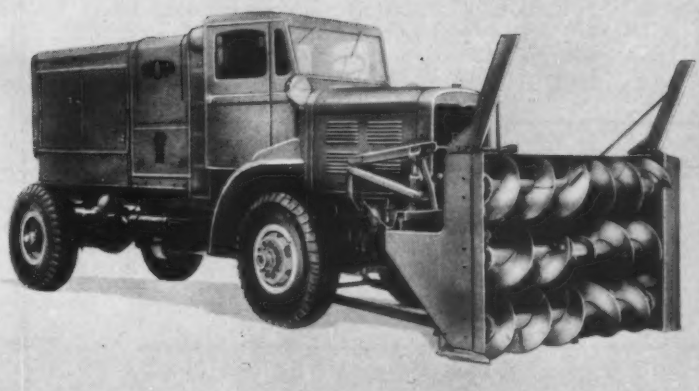
SHUTTLE VALVE — Designed for aircraft application, where high pressure air is used for emergency operation of landing gear. Constructed so that hydraulic inlet is sealed off before air inlet opens, thus preventing mixing of air and oil.



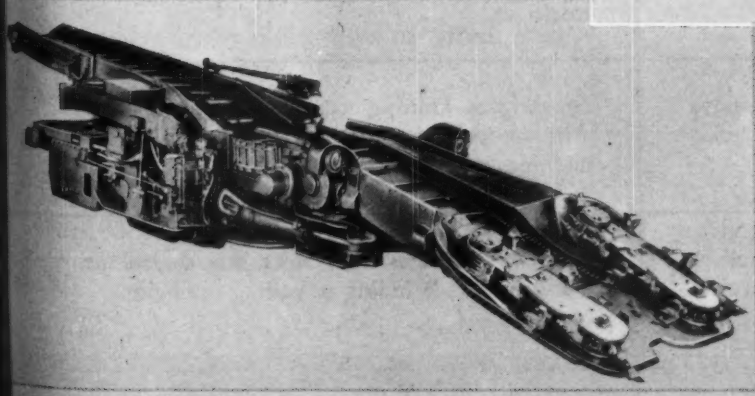


SELECTOR VALVE —For aircraft use. Design eliminates poppets and spools, utilizes rubber doughnut seals. Construction is simplified; cost reduced.

• Considerable development work is now being done by aircraft companies and suppliers on high-pressure hydraulic systems operating at 3,000 lb. per sq. in. pressures. New filtering mediums and devices are being studied, and special attention is being given to seals and sealing materials.



Snow removal equipment utilizing hydraulic power. Hydraulically operated rams mounted on the rear of the plow structure, control the direction of the spout discharging the snow and also control the raising and lowering of the plow.



Machine for loading coal in which hydraulic equipment provides the means and controls for positioning the sections of the loader as required. The loader end may be swung to any position (in the predetermined range) both on a horizontal and vertical plane.

LINEAR MOTION

FUNCTION	APPLICATION
1. Applying large forces through long strokes at variable speeds.	Broaching machines . . . Forcing presses . . . Drawing presses . . . Stretching machines . . . Extruding presses . . . Elevators.
2. Moving a machine head, table, or carriage through a cycle requiring rapid traverse, one or more adjustable feed rates. Utilizes electrical or cam control.	Drilling and boring machines . . . Lathes . . . Extrusion presses . . . Welding machines . . . Cold saws and cutting-off machines . . . Milling machines . . . Swaging machines . . . Electroplate shaving machines . . . Scalping machines.
3. Continuous or intermittent reciprocating motion of light or heavy machine tables or parts at constant or variable velocity.	Surface grinding machines . . . Honing machines . . . Billet pushers . . . Internal grinding machines . . . Planers and slotters . . . Wear testing machines.
4. Motion of light or heavy forces requiring accurate positioning or control of speed in response to automatic electric, pneumatic hydraulic or steam controls.	Stoker drives . . . Leveling and steering equipment for large excavators . . . Tunnel kiln pushers . . . Large door and gate operators . . . Marine steering gears . . . Frequency control on large generators through stator adjustment . . . Furnace and ladle-tilting mechanisms.
5. Motion through semi-automatic or automatic stroke cycle requiring rapid advance with application of heavy forces at reduced speeds.	Flash or butt-welding machines . . . Forming presses . . . Drawing presses . . . Die-casting machines . . . Riveting presses . . . Straightening presses . . . Restriking presses . . . Foundry mold presses.
6. Application of accurately variable pressure forces.	Straightening presses . . . Molding presses . . . Press rolls on textile and paper calenders and paper mills . . . Assembling machines . . . Testing machines . . . Hydraulic cushions on mechanical presses . . . Matrix presses . . . Pulp grinders.
7. Reciprocating or intermittent motion at constant or variable speed, synchronized with other motions or operations.	Conveyors . . . Walking beam furnace drives . . . Briquetting machines . . . Press feeding mechanisms . . . Assembling machines . . . Automatic machinery for innumerable purposes . . . Oven car pushers . . . Ammunition hoists . . . Bottling and filling machines . . . Transfer and handling apparatus . . . Paper container machines.
8. High velocity, intermittent cycles of light or heavy forces applied through a portion or all of the stroke.	Braiding or knitting machines shuttle operation . . . Airplane catapults . . . Brass or magnesium die-casting machines.
9. Application of motion at variable rate of speed or at variable pressure in accordance with mechanical follower on template.	Profiling machines . . . Stock box control on paper machines . . . Winding or coiling machines.

ROTARY MOTION

FUNCTION	APPLICATION
1. Continuous automatic reversing drives requiring constant or variable speed.	Long machine table drives such as grinding machines and planers . . . Dry cleaning machines . . . Agitators:
2. Unidirectional or reversing drives requiring wide range of speed variation.	
(a) Where speed must be controlled automatically by light mechanical forces, or in response to electric, pneumatic, hydraulic or steam-actuated control devices.	Canning or packing machinery . . . Stokers . . . Textile machinery . . . Welding positioners . . . Wire and cable machinery . . . Conveyors . . . Paper making processing or converting machinery . . . Gun turrets fire control . . . Rubber tire processing machinery.
(b) Where speed and direction of rotation must be controlled from remote point.	Printing press drives . . . Flood control gate operator . . . Double-leaf bascule bridge drive.
(c) Where acceleration, deceleration or change in speed must be accurately and automatically controlled.	Winding machinery . . . Special turning machines . . . Large machine tool feeds . . . Rotary surface grinders . . . Aluminum foil laminating machines.
(d) Where fast, smooth deceleration (braking) is essential.	Newspaper printing presses . . . Strip galvanizing machines . . . Centrifugal casting machines.
(e) Where accurate speed control is required over wide range with manual control.	Testing machines.
3. Unidirectional or reversing drives of constant or variable speed, for hazardous locations (where electrical equipment is prohibited.)	Mixers . . . Pulverizers . . . Presses or conveyors in explosives manufacturing plants . . . Mills . . . Centrifugals.
4. Unidirectional or reversing drives of variable speed, requiring "constant horsepower" output through all or portion of speed range.	Lathes . . . Elevators . . . Windlasses and winches . . . Hoists . . . Wire and cable machinery . . . Reels and coiling machines.
5. Unidirectional or reversing drives of variable speed, requiring automatic control of torque.	Constant tension reel and winder drives . . . Paper or rubber processing machinery.
6. Unidirectional drives of variable speed, requiring exceptionally accurate matching of output speed with other rotating elements.	Sectional paper machine drives . . . Wire and cable machinery . . . Winding machinery . . . Cellophane, paper and rubber processing machines . . . Textile machinery.

Courtesy Oilgear Company

Manufacturers

OF HYDRAULIC CONTROLS AND ASSEMBLIES

★

Adel Precision Prods. Corp.....Burbank, Calif.
Aeroquip Corp.....Jackson, Mich.
Air Associates, Inc.....Bendix, N. J.
Aircraft Industries Corp.....Tenafly, N. J.
Aircraft Parts Prod. Corp.....Ann Arbor, Mich.
Aircraft Specialties Co.....Los Angeles, Calif.
American Engineering Co.....Philadelphia, Pa.
Barnes Corp., John S.....Rockford, Ill.
Bendix Aviation, Ltd.....No. Hollywood, Calif.
Bendix Products Div.....S. Bend, Indiana
Bowser & Co., S. F.....Ft. Wayne, Indiana
Brown & Sharpe Mfg. Co.....Providence, R. I.
Cash Co., A. W.....Decatur, Ill.
Chicago Metal Hose Corp.....Maywood, Ill.
Clarke-Aero Hydraulics, Inc.....Pasadena, Calif.
Cleveland Pneumatic Tool Co.....Cleveland, Ohio
Columbia Aircraft Prods. Inc.....Somerville, N. J.
Cosco Mfg. Co.....Los Angeles, Calif.
Cuno Engineering Corp.....Meriden, Conn.
Denison Engrg. Co., The.....Columbus, Ohio
Dole Valve Co., The.....Chicago, Ill.
Eclipse Aviation-Pioneer Instr.....Bendix, N. J.
Electrol Inc.....Kingston, N. Y.
Fleetwings, Inc.....Bristol, Pa.
Gardner-Denver Co.....Quincy, Ill.
Geroter May Co.....Baltimore, Md.
Hanna Eng. Works.....Chicago, Ill.
Hannifin Mfg. Co.....Chicago, Ill.
Harvill Corp.....Los Angeles, Calif.
Hayes Mfg. Co.....Grand Rapids, Mich.
Houde Engrg. Div.....Buffalo, N. Y.
Hub Industries Inc.....Long Island City, N. Y.
Hydramotive Inc.....Detroit, Mich.
Hydraulic Controls.....Chicago, Ill.
Hydraulic Hi-Speed.....Detroit, Mich.
Hydraulic Machinery Inc.....Dearborn, Mich.
Hydro-Power Systems, Inc.....Gilead, Ohio
Ideal Roller & Mfg. Co.....Chicago, Ill.
Interstate Aircraft & Engrg.....Los Angeles, Calif.
Kenyon Instr. Co., Inc.....Long Island, N. Y.
Linear Packing & Rubber Co.....Philadelphia, Pa.
Logansport Machine, Inc.....Logansport, Ind.
Luscombe Airplane Corp.....Trenton, N. J.
Maytag Co., The.....Newton, Iowa
Ohio Piston Co., The.....Cleveland, Ohio
Oilgear Corp.....Milwaukee, Wis.
Pacific Aviation, Inc.....Los Angeles, Calif.
Parker Appliance Co., The.....Cleveland, Ohio
Peerless Machine Co.....Racine, Wis.
Pesco Products, Inc.....Cleveland, Ohio
Purolator Products, Inc.....Newark, N. J.
Racine Tool & Machine Co.....Racine, Wis.
Roper Corp., George D.....Rockford, Ill.
Scott Aviation Corp.....Lancaster, N. Y.
Simmons Mfg. Co., The.....Ashland, Ohio
Simmonds Aerocessories, Inc.....New York, N. Y.
Sundstrand Machine Tool Co.....Rockford, Ill.
Thompson Products, Inc.....Cleveland, Ohio
Tubing Seal-Cap, Inc.....Los Angeles, Calif.
Vickers, Inc.....Detroit, Mich.
Westinghouse Air Brake Co.....Wilmerding, Pa.

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Simplified Method For Designing Beam Sections — II

WILLIAM L. GOVAN
Engineer, Dominion Engineering Works Limited

Procedure for checking and adjusting the preliminary proportions of beam sections as obtained by the equations developed in Part I, with a summary of the complete method for designing a satisfactory section. Practical design considerations are enumerated which may dictate modifications in final proportions.

UNLESS only an approximation is desired, the actual section modulus of the beam should be calculated both as a check on the previous work, which was developed and explained in Part I, PRODUCT ENGINEERING, January, 1944, page 26, and as a preliminary step in making the final correction if required. Equations for section modulus should be written in a form to employ previous calculations thus enabling corrections to be made with small effort. Derivation of the moment of inertia by the exact formula is

$$I = A_t p^2 + A_c q^2 + A_w z^2 + (A_w d^2 + A_t t_t^2 + A_c t_c^2)/12 \quad (23)$$

Eliminating A_c by use of Equation (7), (see Part I)

$$I = A_t p^2 + A_t p q - A_w z q + A_w z^2 + \frac{A_w d^2 + A_t t_t^2}{12} + \frac{A_t p t_c^2 - A_w z t_c^2}{12q} \quad (23a)$$

$$Z_t = \frac{I}{x} = \frac{A_t}{x}\left(p^2 + p q + \frac{t_t^2}{12} + \frac{p t_c^2}{12q}\right) + \frac{A_w}{x}\left(z^2 - z q + \frac{d^2}{12} - \frac{z t_c^2}{12q}\right) \quad (24)$$

This can be expressed in the convenient form

$$Z_t = b_t Q + N \quad (25)$$

Three degrees of accuracy are in common use:

1. For thin flanges the individual moment of inertia of each flange about its own center may be neglected: this is accurate enough for all practical purposes. For this approximation

$$Q' = t_t p (p + q)/x \quad (26)$$

$$N' = \frac{A_w}{x}\left(z^2 - z q + \frac{d^2}{12}\right) \quad (27)$$

2. For unsymmetrical sections with thick tension flanges, the individual moment of inertia of a thin compression flange about its own center may still be ignored. For this approximation

$$Q'' = Q' + \frac{t_t^3}{12x} = \frac{t_t}{x}\left(p^2 + p q + \frac{t_t^2}{12}\right) \quad (26a)$$

Term N is defined by Equation (27).

3. For unsymmetrical sections with both flanges very thick the values are

$$Q''' = Q'' + \frac{t_t t_c^2 p}{12q x} = \frac{t_t}{x}\left(p^2 + p q + \frac{t_t^2}{12} + \frac{p t_c^2}{12q}\right) \quad (26b)$$

$$N''' = N' - \frac{A_w z t_c^2}{12q x} = \frac{A_w}{x}\left(z^2 - z q + \frac{d^2}{12} - \frac{z t_c^2}{12q}\right) \quad (27b)$$

For symmetrical sections with very thick flanges, where t_f is the thickness of one flange, and A_f is the area of one flange, the exact equations reduce to

$$Q''' = t_f[d(1-m)^2 + m^2 d/3] = t_f[d - t_f(2 - 1.33m)] \quad (26c)$$

$$N''' = A_w d/6 \quad (27c)$$

or

$$Z_t = Z_c = A_f[d - t_f(2 - 1.33m)] + A_w d/6 \quad (28)$$

Actual Section Modulus

The actual section modulus is determined from these equations and subtracted from the required value or vice versa. If there is sufficient difference to require correction

$$\Delta Z = \text{Required } Z_1 - \text{Actual } Z_2 \quad (29)$$
$$= (b_1 Q + N) - (b_2 Q + N)$$
$$= (b_1 - b_2) Q = \Delta b_t Q$$

Therefore

$$\Delta b_t = \Delta Z_t / Q \quad (30)$$

This method of correction requires that all adjustment be made by altering the width of the flanges. There is not much work involved in this step as Q has already been calculated. The final result is theoretically correct provided there is no change in the metal thicknesses.

The compression flange for unsymmetrical sections must also be altered to maintain the same neutral axis, in accordance with Equation (19); (see Part I, PRODUCT ENGINEERING, January, 1944, page 26):

$$\Delta b_c = b_{c1} - b_{c2} = \frac{A_{t1} p - A_w z}{t_c q} - \frac{A_{t2} p - A_w z}{t_c q} = \frac{\Delta b_t t_t p}{t_c q} \quad (31)$$

Thus an exactly correct section is obtained with no wasted steps unless for some unusual reason it is found necessary to alter the original assumed depth, thickness of web or flanges.

Combined Bending and Direct Load

When proportioning flanges for combined bending and direct load proceed as previously as far as but not including Equation (6), [see Part I, PRODUCT ENGINEERING, January, 1944, page 27]. The corresponding equation for either tension or compression flange area is then developed.

P = direct or axial load, lb.
M = bending moment on section, in. lb.
A = area of total section, sq. in.
A_1 = area of single flange, sq. in.
A_t = area of tension flange, sq. in.
A_c = area of compression flange, sq. in.
A_w = area of web section, sq. in.
$C = A/A_f$. This ratio usually varies between 1½ and 4 for beams, always more than 2 for symmetrical sections, and sometimes more than 4 when bending is relatively small compared to direct load.
d = depth of total section, in.
Z = section modulus, in.³
s_c = combined stress caused by bending and direct load, lb. per sq. in.
s_b = stress caused by bending alone, lb. per sq. in.
s_d = stress caused by direct load alone, lb. per sq. in.

Then

$$s_c = s_b + s_d = \frac{M}{Z} + \frac{P}{A} \quad (32)$$
$$= \frac{M}{A_f d} + \frac{P}{A_t + A_c + A_w} = \frac{M}{A_f d} + \frac{P}{A_f C}$$

The ratio C must be assumed for the

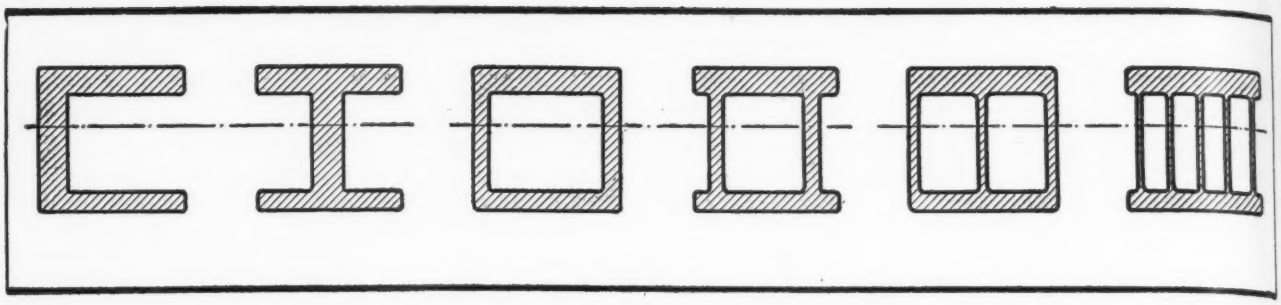


Fig. 8—Channel, I, and box sections having the same section modulus.

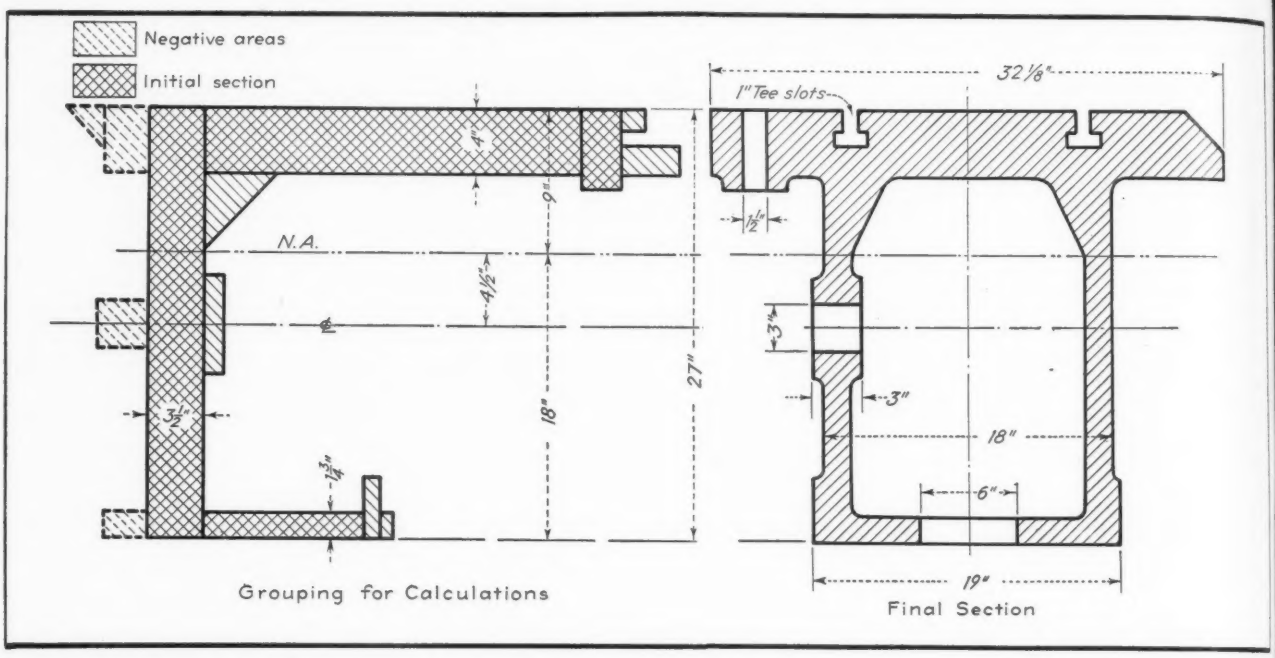


Fig. 9—Method of developing a complicated section by grouping flange and web components into a composite channel section.

first approximation for the relation

$$A_{f1} = \frac{M}{s_t\, d} + \frac{P}{s_t\, C_1} \qquad (33)$$

From this approximation for flange area A_{f1} select flange width b and thickness t and if the section appears to be impractical, revise the assumed depth d and web area A_w at this early stage. As all areas are then known approximately for symmetrical sections, and all but the compression flange for unsymmetrical, it is possible to revise constant C. At the same time apply the correction factor from the charts of Figs. 3 to 7 or the Equations (17), (see Part I), Equation (33) then becomes

$$A_{f2} = \frac{M}{s_t\, K\, d} + \frac{P}{s_t\, C_2} \qquad (34)$$

If the first assumption for C was greatly in error, and the stress caused by direct loading is unusually large compared to the flexural stress, there will be considerable difference between the results of Equations (33) and (34). Hence constant C will still be in error, and will require revision a second time.

The opposite flange for unsymmetrical sections is determined by Equation (19) as before (see Part I). If the tension flange is modified at any time, Equation (31) is used to make a corresponding correction to the compression flange.

Next calculate the actual area and actual section modulus using Equation (25) and check the stress by Equation (32). If there is much discrepancy between the actual stress and the desired stress, correction is made

$$\frac{\text{Required } A_f}{\text{Actual } A_f} = \frac{\text{Actual } s_t\,(M/K\,d + P/C)}{\text{Required } s_t\,(M/K\,d + P/C)}$$

Neglecting the change in constant C, and as K is constant if flange thickness is not changed,

$$\text{Required } b_f = \text{Actual } b_f \times \text{Actual } s_t / \text{Required } s_t \qquad (35)$$

This cannot be as exact as Equation (30) for simple bending as any change to the section affects C. In most cases Equation (35) will reduce the error to 1 or 2 percent, which is accurate enough for most purposes. In a few cases, Equation (35) may have to be repeated.

The Equation (35) can be expressed in terms of flange area rather than widths: in which case the error is slightly greater as K will also change.

This method for proportioning beam sections applies equally to channel, I or box sections like those shown in Fig. 8. These all have the same section modulus in the principal plane of bending if the total flanges and the sum of the web thicknesses are the same.

Complicated sections which cannot be reduced to simple rectangular webs and flanges also can be usually approximated by this method, then checked and corrected, especially if unsymmetrical. The procedure can be explained by reference to Fig. 9. Break down the section to a channel form by adding all webs together and regrouping all flange component parts on one side of the composite web so formed. Divide the section into rectangles and triangles, running the web and as many other parts as possible right out to the extreme fiber. In finding the center of gravity, the quickest method is usually to take moments about the center line. This insures that the majority of component parts will have zero moment.

If it is found necessary to modify the

tension flange, alter the compression flange also in a way such as to maintain unchanged the location of the neutral axis. Alter the width of the flanges if possible rather than the thickness. If these methods are followed, alterations to the section involve only the addition of small amounts to the calculation. Even if flange thickness has to be changed, values for the web and similar component parts remain unaffected.

Flange width on each side of each web center line should not be greater than half the section depth, nor more than twelve times the web thickness. These are conservative, arbitrary proportions. If a wider flange is used for reasons other than strength only the portion within these limits should be considered entirely effective. If depth is limited requiring wide flanges use I-section instead of channel, box instead of I-section, box with overhung flanges, or box with multiple webs as required.

Gross widths of flanges are reduced by the sum of the widths of any holes they may contain. Such holes should be made round, or oval with the major diameter in line with the direction of the stress so as to reduce destructive stress concentrations. For the same reason holes should be beaded around the edges if at all practical to do so, especially in the flanges but also in the

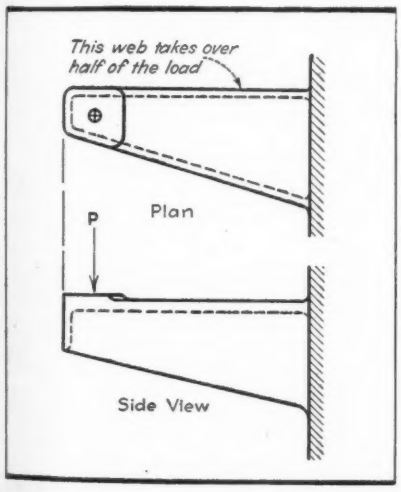


Fig. 10—Overhanging arm in which the load is transmitted to the reactions by more than one route.

webs. Flange holes should be at points where the bending moment is low, usually remote from mid-span. Web holes should be at points of zero or low shear, often at mid-span.

Minimum metal thickness in castings is set by foundry practice. It is unusual to make a flange thinner than any single web. Large fillets or corner wedges must be provided wherever a heavy flange joins a light web. On complicated shapes allowance should be made so that slight core shifting can not result in dangerously thin walls. Similarly, draft must be considered and should be shown on drawings at critical sections, not left to the discretion of the pattern maker who may not realize the stresses involved. Ample support must be provided for all cores. Objectionable cored holes can be plugged if necessary.

For long span beams where span is greater than 15 times the total flange width, the permissible compressive stress should be reduced by column formula unless the flange is stiffened to prevent buckling. This condition is unusual in machine design, but common in structures.

At points of loading treat the web as a column with fixed ends, having a length equal to clear distance between the flanges, and a width equal to length of bearing plus a quarter of the depth on each side provided the web extends on both sides. The web is usually provided with transverse rib stiffeners at such points.

In certain designs it will be found that the loads are transmitted to the reactions by more than one route, and some routes will be more direct than others, as in Fig. 10. In such cases the various routes will carry the load in proportion to their relative stiffness or resistance to deflection. This applies not only to flexural stress but also to shear in the webs.

Table I—Summary of Method

1. Calculate loads and bending moments and assume depth of section and if section is unsymmetrical the location of neutral axis.

$$\frac{S_c}{S_t} = \frac{Z_t}{Z_c} = \frac{1-k}{k} = \frac{y}{x} \qquad (2)$$

If assumption is impracticable, it will be seen after Step No. 4.

2. Calculate web thickness $t_w = W/s_s d$ (4)

For bending with direct load assume factor C.

3. Determine flange area

For bending only

$$A_f = Z/d = M/sd \qquad (6)$$

For bending with direct load

$$A_n = \frac{M}{s_s d} + \frac{P}{s_c C_1} \qquad (33)$$

4. Assume flange thickness and then determine width.

5. Find correction factor K **from charts or**

$$Z_t/Z_c = 1, \quad K = 1.2 - 1.7m \qquad (17a)$$
$$Z_t/Z_c = 1\tfrac{1}{3}, \quad K = 1.1 - 1.7m \qquad (17b)$$
$$Z_t/Z_c = 1\tfrac{2}{3}, \quad K = 1.03 - 1.7m \qquad (17c)$$
$$Z_t/Z_c = 2, \quad K = 0.98 - 1.7m \qquad (17d)$$

For bending with direct load revise factor C **here, and also after Steps 6 and 7 if a large error in** C **is greatly affecting the result in case of relatively large direct loading.**

6. Modify flange width or area

For bending only

$$b_2 = b_1/K \qquad (18)$$

For bending with direct load

$$A_{n2} = \frac{M}{s_s K d} + \frac{P}{s_c C_2} \qquad (34)$$

7. For unsymmetrical sections assume compression flange thickness and determine width

$$b_c = (A_t p - A_w x)/t_c q \qquad (19)$$

8. Find actual section modulus

$$Z_t = b_t Q + N \qquad (25)$$

8a. For bending with direct load find actual area and stress

$$s_c = \frac{M}{Z} + \frac{P}{A} \qquad (32)$$

9. Correct tension flange width or area

For bending only

$$\Delta b_t = \Delta Z_t/Q \qquad (30)$$

For bending with direct load

$$b_2 = b_1 \times \frac{\text{Actual Stress}}{\text{Required Stress}} \qquad (35)$$

10. For unsymmetrical sections correct compression flange

$$\Delta b_c = \frac{\Delta b_t t_t p}{t_c q} \qquad (31)$$

Curved Flange Calculation For Sheet-Metal Parts

When design of sheet-metal parts calls for curved flanges, the allowable shrink or stretch in the flange depends on a number of factors that can be taken into account readily by the systematic approach with formulas and examples that are outlined. The chief object is flange design that minimizes production difficulties.

FRANK M. MALLETT
Curtiss-Wright Corporation

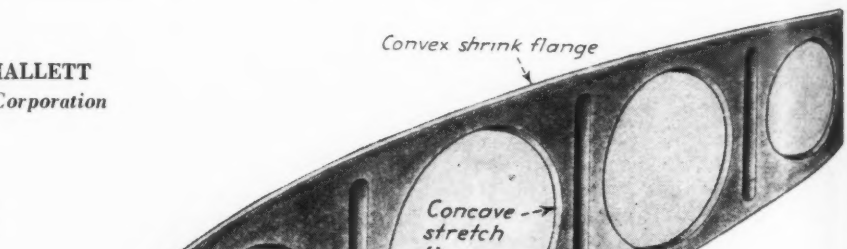


Fig. 1—Former rib for airplane wing has flanges both for stiffening and means of attachment. Beads further reinforce the rib.

IN sheet-metal parts flanges serve as stiffeners and means of attachment to adjoining parts. When they are straight, and forming involves only bending, there are no design difficulties. But the forming of flanges on a curved line involves shrinking or stretching the flange metal depending on whether the flange is convex or concave. Shrinking and stretching curved flanges present forming difficulties and are limiting factors in design and production of sheet-metal parts. Designs that avoid exceeding maximum allowable stretch or shrink vary with the available tools, presses, and shop experience. Nevertheless the problem can be approached systematically and a solution obtained by a convenient and precise method.

Difficult forming jobs are sometimes necessary but they often occur only because their difficulty was not appreciated by the designer. Difficult or impossible designs cause production delays: By time lost for redesign, for making complicated rather than simple tools, by time spent in developing special tools and methods, and finally in production time lost directly in making difficult parts instead of simpler parts.

Notation used in computation for flange design is shown in Fig. 2. Leg widths A and W of an angle add up to more than the flat width. The amount to be subtracted from $A + W$ to give the flat width is called setback, or bend deduction, and is denoted by S. In flat pattern layout work it is customary to lay out the width A of one leg and to subtract the setback S from the flange width W, denoting the resulting "flat pattern flange width" by Y. $W - S = Y$. Setback is a function of bend angle θ, bend radius R, and stock thickness.

$$S = 2\,(R + T)\tan\,(45 + \theta/2) - 0.01745\,(R + 0.446T)\,(90 + \theta)$$

Nominal elongation or shrink for 90-deg. flanges with mold line a circular arc, as in Fig. 3, can be readily computed for any angular portion ω of a continuous flange. In a shrink flange, nominal unit shrink C is:

$$C = \frac{\omega R_E - \omega R_M}{\omega R_E}$$

where ω is measured in radians.

Since in a shrink flange $R_E - R_M = Y$, the flat pattern flange width:

$$C = \frac{Y}{R_M + Y}$$

Solving for Y and R_M

$$Y = \frac{C}{1 - C} R_M$$

$$R = \frac{1 - C}{C} Y$$

In the stretch flange of Fig. 3(*B*): $Y = R_M - R_E$, and the nominal unit elongation E is:

$$E = \frac{\omega R_M - \omega R_E}{\omega R_E} = \frac{Y}{R_M - Y}$$

Solving for Y and R_M

$$Y = \frac{E}{1 + E} R_M$$

$$R_M = \frac{1 + E}{E} Y$$

When curved flanges are not arcs of circles the deformation varies from point to point along the mold line M but can be approximated at any point by using the radius of curvature at that point. This radius can be estimated closely enough for most purposes.

Nominal elongation or shrink for open flanges, with mold line a circular arc, can be computed similarly. The length of the edge of the flange in flat pattern is changed to that of an arc of radius R_V in Fig. 4. Nominal shrink C is then:

$$C = \frac{\omega R_E - \omega R_V}{\omega R_E}$$

Since $R_V = R_M + V$, $R_E = R_M + Y$, and $V = W \sin\theta$

$$C = \frac{Y - W \sin\theta}{R_M + Y} = C_{90} - \frac{V}{R_M + Y} \text{ for open flanges}$$

$$R_M = R_{90} - \frac{V}{C}$$

In the stretch flange the elongation E is:

$$E = \frac{\omega R_V - \omega R_E}{\omega R_E}$$

Since $R_M = R_V + V = R_E + Y$ and $V = W \sin\theta$

$$E = \frac{Y - W \sin\theta}{R_M - Y} = E_{90} - \frac{V}{R_M - Y} \text{ for open flanges}$$

$$R_M = R_{90} - \frac{V}{E}$$

Nominal elongation or shrink for

closed flanges are computed from dimensions shown in Fig. 5. The basic formulas for C and E are the same as above, but there are the following differences:

For shrink $R_V = R_M - V$

For stretch $R_M = R_V - V$

These give

$$C = \frac{Y + W \sin \theta}{R_M + Y} = C_{90} + \frac{V}{R_M + Y}$$

$$R_M = R_{90} + \frac{V}{C}$$

$$E = \frac{Y + W \sin \theta}{R_M - Y} = E_{90} + \frac{V}{R_M - Y}$$

$$R_M = R_{90} + \frac{V}{E}$$

These general formulas become the same as those for flat or open flanges if the sign of θ is assumed to be negative for open flanges, 0 for 90 deg. flanges, and positive for closed flanges. They are a means for determining shrink and elongation in curved flanges when flange width and bevel, and mold line radius are known. However, in solving design problems it is more useful to set maximum values for shrink and elongation so that a flange width and mold line fitting functional needs of the part may be determined without exceeding maximum deformation.

Since maximum permissible deformation depends on many variables, values shown on the 90-deg. flange nomogram can be used as guides in determining sets of maxima for given circumstances.

In designing parts with curved flanges a certain shape may be required, which necessitates determining the maximum flange that can be formed. If a certain flange width is required, the mold line radius must be determined. A more difficult problem arises when requirements for both of these variables are predetermined and it is necessary to compromise between the two. There is no easy method of solving all such problems but if the systematic method of approach that is outlined here is used it provides all of the facts, which is the first step in solving any problem.

Other features of design sometimes affect the forming of curved flanges. Most important are free ends or breaks in a flange. These prevent complete shrink or elongation so that there is less than the formulas above indicate. The shrink formula can be altered to allow for the amount A of reduction in shrink or elongation.

$$C' = C - \frac{2A}{\omega R_E}$$

The value of A depends on many variables, but usually ranges from 0.1 to 0.2 times flange width. In the flange of Fig. 3(A), with $W = 0.6$, actual measurements of a series of flanges yielded the following reductions of C, which are satisfactory for most purposes.

Flange Length Inches	$C - C'$ Percent
20	$\frac{1}{2}$
10	1
5	2
2	4
$\frac{1}{2}$	8

Unit elongation in stretch flanges is reduced the same way.

One method of avoiding difficult or impossible shrink forming is to scallop the flange, as in Fig. 6. Scalloping takes advantage of the great reduction in shrink effected by short flange lengths. It provides edge distance for rivet holes but because effective width of flange is reduced, shrink is reduced. However, it also reduces the stiffening effect of the flange.

Another method is to put fluted cutouts in the block, which makes the flange wavy, as shown in Fig. 6, and decreases the amount of shrink needed. This also weakens the flange as a stiffening element. Both methods are useful where flange width is needed for rivet edge distance rather than for stiffness.

The following typical problems in designing flanges can be solved simply by nomograms.

1. Find stretch or shrink of a 90-deg. flange when mold line radius R_M and flange width W are known.

First determine the setback S (or

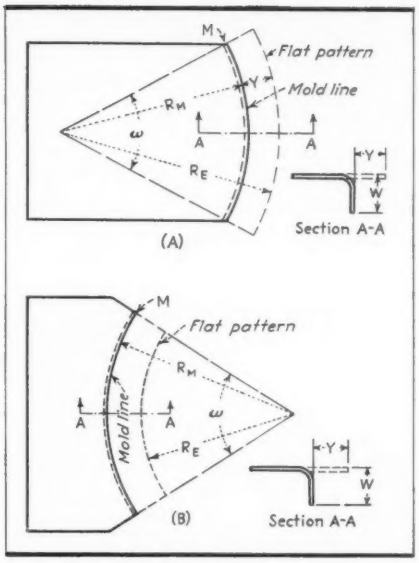


Fig. 3—90-deg. flange notation.

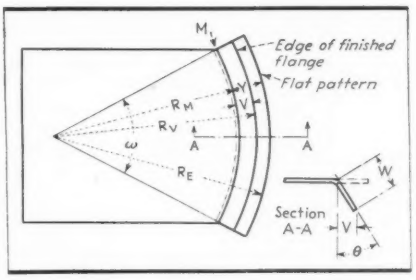


Fig. 4—Open flange notation.

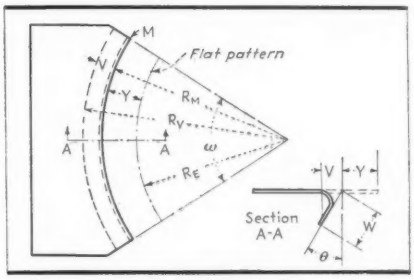


Fig. 5—Closed flange notation.

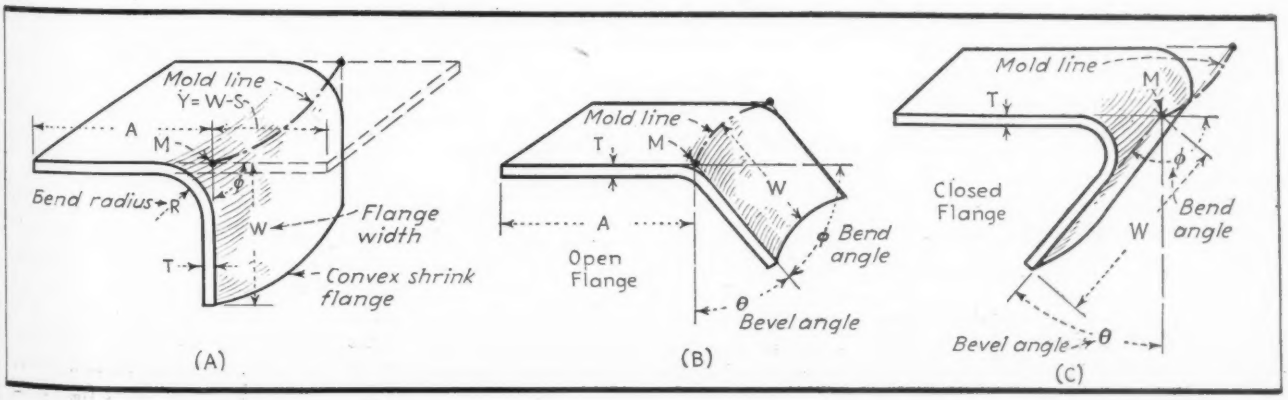
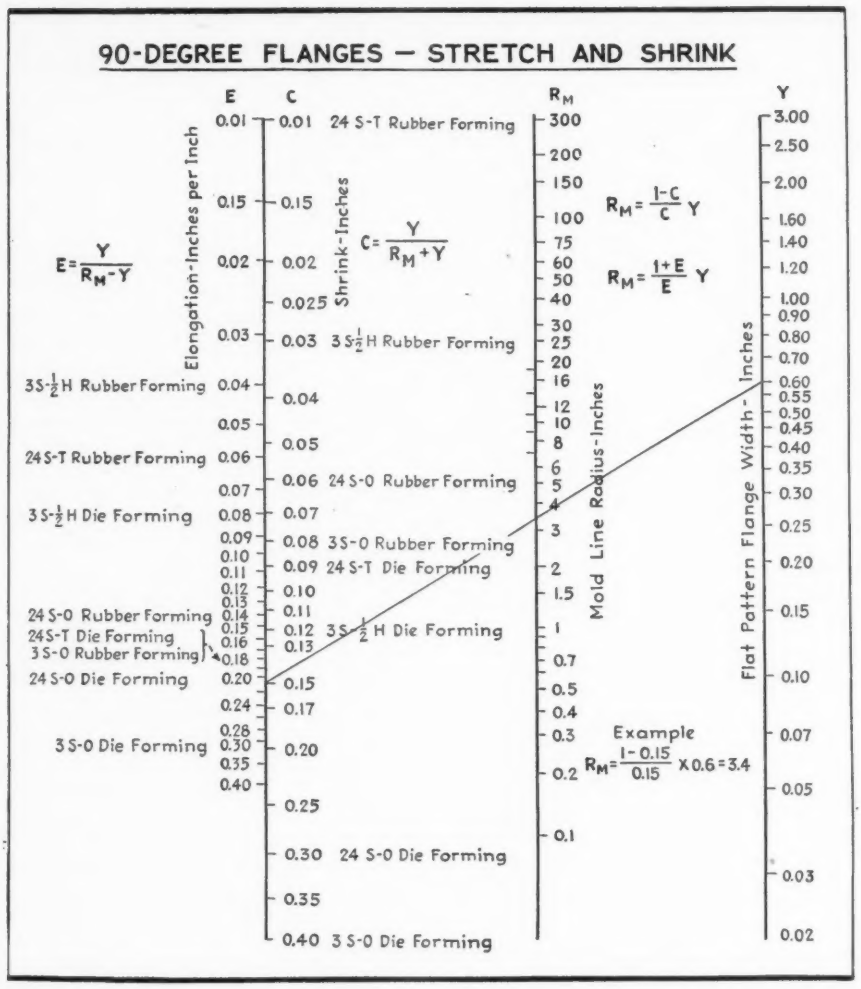


Fig. 2—Flange notation, terms and symbols.



bend reduction) corresponding to the bend radius and stock thickness, and subtract from W. $W - S = Y$. Assume $Y = 0.60$ and $R = 3.4$. A line through these values on the nomogram for 90-deg. flanges gives $E = 0.214$ in. per in. or $C = 0.15$ in. per in.

2. Find flange width W of a 90-deg. flange when E or C and R_m are given. Read Y from chart for 90-deg. flanges, add setback S to get W.

3. Find mold line radius R_m of a 90-deg. flange when E or C and W are given. Find Y as in 1, read R from chart for 90-deg. flanges.

4. Find stretch E of an open bevel flange when W, θ and R_m are given.

First determine setback S corresponding to bend radius, stock thickness and angle θ, and subtract from W. $W - S = Y$. Use this Y and R_M on chart for 90-deg. flanges to get E_{90}, determine $R_m - Y$, and locate result on X scale of correction factor chart. The desired $E = E_{90} - \frac{W \sin \theta}{R_m - Y}$. Find V on correction factor chart by a line across W and θ scales, then a correction factor K by a line through V on the V-scale and $(R_m - Y)$ on X-scale.

$$E = E_9 - K.$$

5. Find R_m of an open bevel flange when W, θ and E (usually a design maximum) are given.

Find Y and R_{90} as in 4. The desired $R_m = R_{90} - \frac{W \sin \theta}{E}$. Find V as in 4, then the correction factor K by a line through V on V-scale and the value of E on the X-scale. $R_m = R_{90} - K$.

6. Find stretch E of a closed bevel flange when W, θ and R are given. Stretch is determined as in 4 except that $E = E_{90} + \frac{W \sin \theta}{R_m - Y}$.

7. Find mold line radius R_m of a closed bevel flange when W, θ and E are given. Radius is determined as in 5 except that $R_m = R_{90} + \frac{W \sin \theta}{E}$.

8. Find shrink C of an open bevel flange when W, θ and R are given. Find Y and C_{90} as in 4. The desired $C = C_{90} - \frac{W \sin \theta}{R_m + Y}$. Find V as in 4, then the correction factor K by using the V-scale and applying $R_m + Y$ to the X-scale. $C = C_{90} - K$.

9. Find mold line radius R_m of an open bevel flange when W, θ and C are given. Find Y and R_{90} as in 4. The desired $R = R_{90} - \frac{W \sin \theta}{C}$. Find V as before, then the correction factor K by using the V-scale and applying C to the X-scale. $R = R_{90} - K$.

10. Find shrink C of a closed bevel flange when W, θ and R are given. Shrink is determined as in 8 except that $C = C_{90} + \frac{W \sin \theta}{R_m + Y}$.

11. Find mold line radius R of a closed-bevel flange when W, θ and C are given. Radius is determined as in 9 except that $R = R_{90} + \frac{W \sin \theta}{C}$.

When flange width W is to be determined for a closed- or open-bevel flange, with R, θ and C given, it is necessary to use a trial and error process when using the nomographic charts. The charts are then used to find Y. $Y = Y_{90} + \frac{W \sin \theta}{1 - C}$

Flange width can also be computed from the following formulas, which are derived from equations for C and E, substituting $W - S$ for Y:

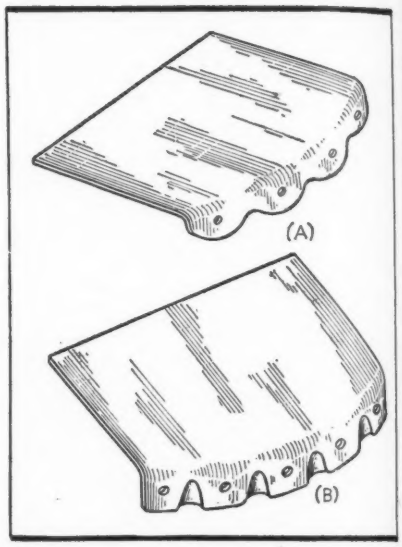


Fig. 6—Scalloped or fluted cutouts avoid difficulty in forming wide flanges but reduce stiffening effect.

Open flange formulas:

$$W = \frac{S(C - 1) - CR}{C - (1 - \sin \theta)}$$

$$W = \frac{S(E + 1) + ER}{E + (1 - \sin \theta)}$$

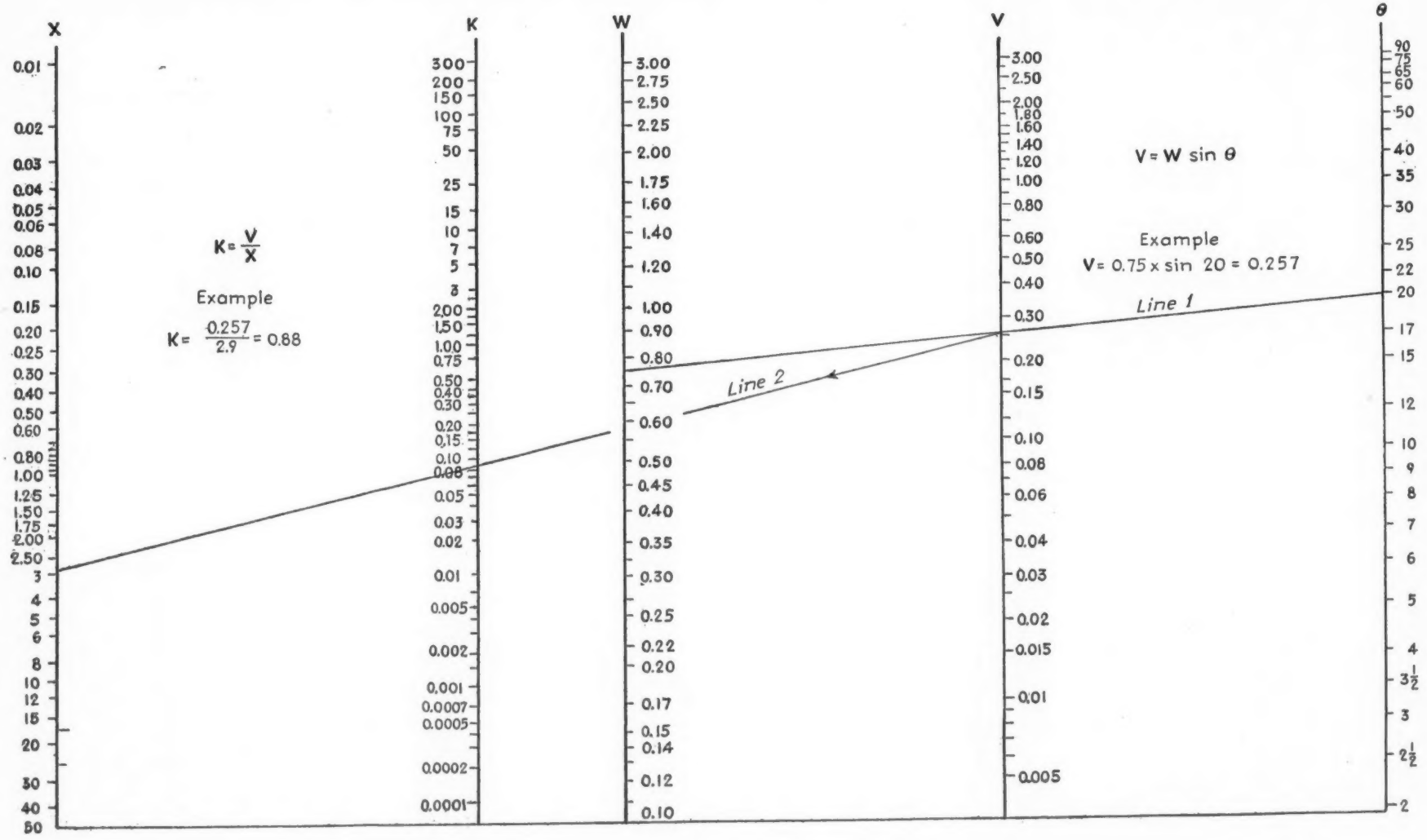
Closed flange formulas:

$$W = \frac{S(C - 1) - CR}{C - (1 + \sin \theta)}$$

$$W = \frac{S(E + 1) + ER}{E + (1 + \sin \theta)}$$

Example 8 is carried out on the two nomograms. Computed flat pattern width $Y = 0.60$ and known $R_m = 3.4$ gives $C_{90} = 0.15$. Known values of W and θ, with the value of $R_m + Y$ located on the X-scale, gives correction factor 0.088 to be subtracted from C_{90}. $C = 0.15 - 0.088 = 0.06$ in. shrink.

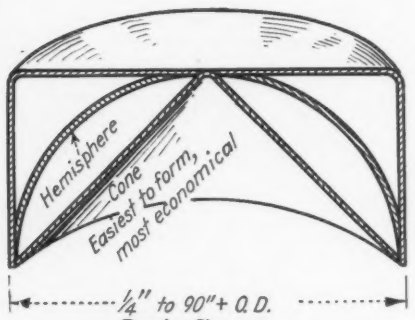
CURVED FLANGES — STRETCH AND SHRINK, CORRECTION FACTORS, OPEN AND CLOSED FLANGES



TYPICAL METAL SPINNINGS—

THE scope of spun sheet-metal parts in product design is shown by sketches representative of the "Spincraft" of Milwaukee Metal Spinning Company. Spinnings are generally limited to round parts or to parts having round details. Segments or sectors of spun shapes are often welded into other formed sheet-metal parts to produce rounded compound-curved contours in machine housings, covers, doors and guards, truck bodies and cabs, and other sheet-metal parts.

In quantities up to at least 1,000, spinnings are usually more economical than stampings. Some are produced in much greater quantity advantageously. Nearly all metals can be spun. Shape, size and gage are interdependent. Thickness can be up to ¼ in. for soft metals, up to $\frac{5}{16}$ in. for low-carbon steel, and up to ⅛ in. for stainless steel. If 2SO aluminum is rated 1.00 in ease of spinning, zinc is 0.94, cold-rolled deep-drawing steel 0.91, cold-rolled annealed copper 0.87, nickel 0.86, and stainless steel, type 347, is 0.67. Technique for spinning magnesium has just been developed, and is now on a production basis.



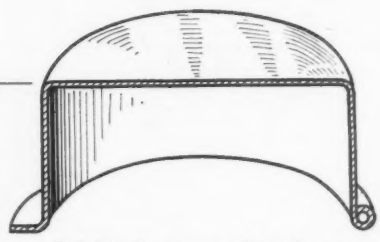
Basic Shapes

Dimensional tolerance range

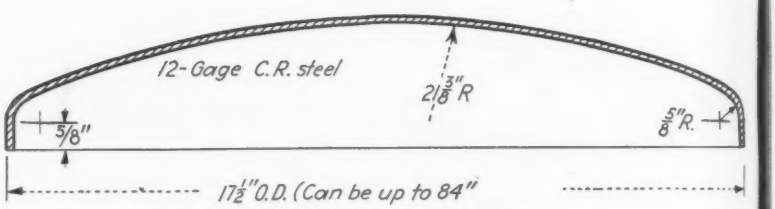
1/16 in.- Large size (commercial)

1/64 in.- Small size (commercial)

0.005 in.- All sizes when required

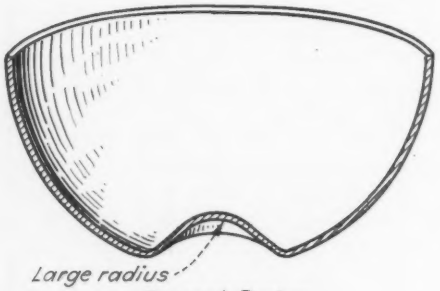


Outside flanges and beads are more economical than inside flanges and beads



Ideal part for spinning

(10-Gage steel with 2" to 3" O.D. unpractical)

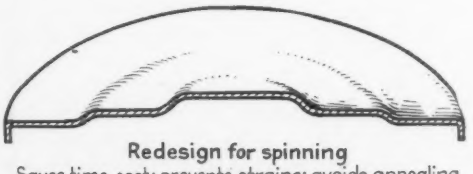


Correct Design

Can be produced on one spinning block

Sharp Identation

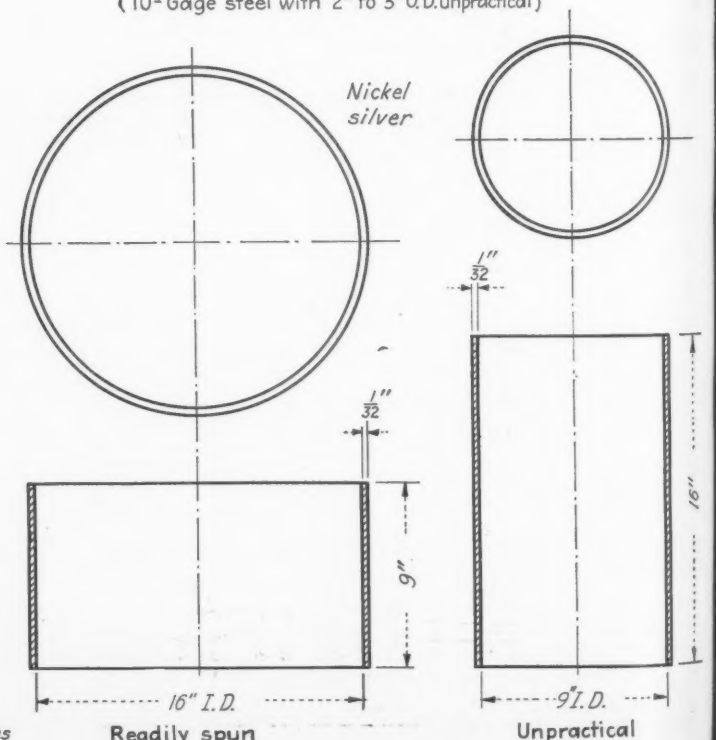
Requires extra spinning block and metal is stretched and thinned



Redesign for spinning

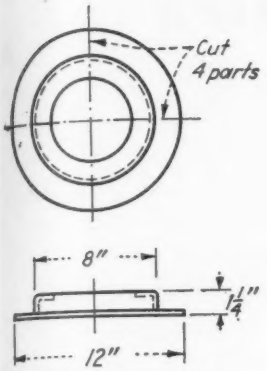
Saves time, cost; prevents strains; avoids annealing

Uneconomical design

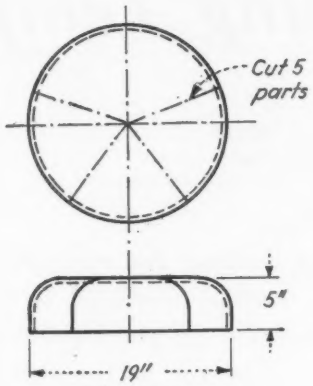


Readily spun **Unpractical**

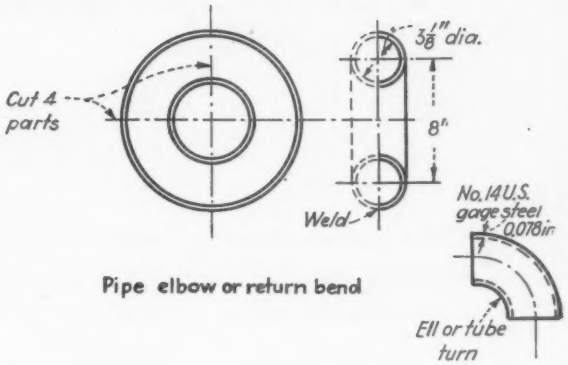
DESIGNS AND APPLICATIONS



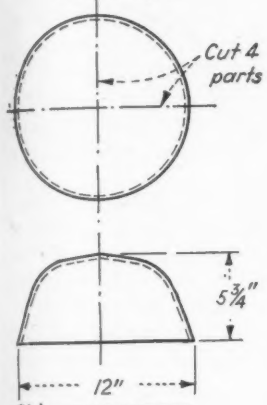
Door corners with stop flanges



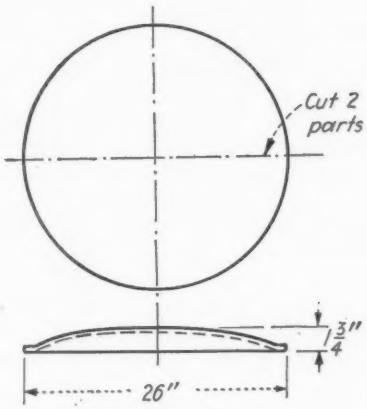
Fender corners



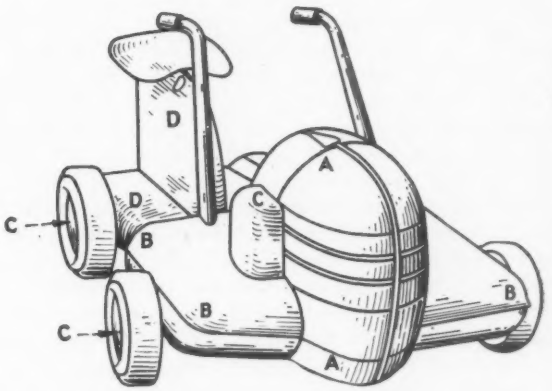
Pipe elbow or return bend

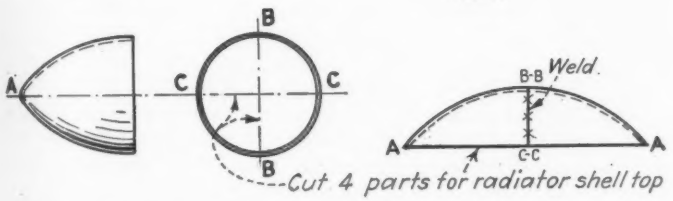


Side apron corners (Rear)

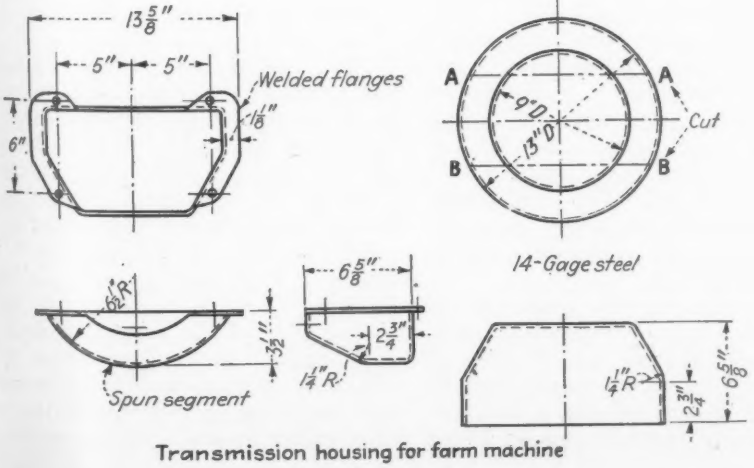


Catwalk end (Rear)

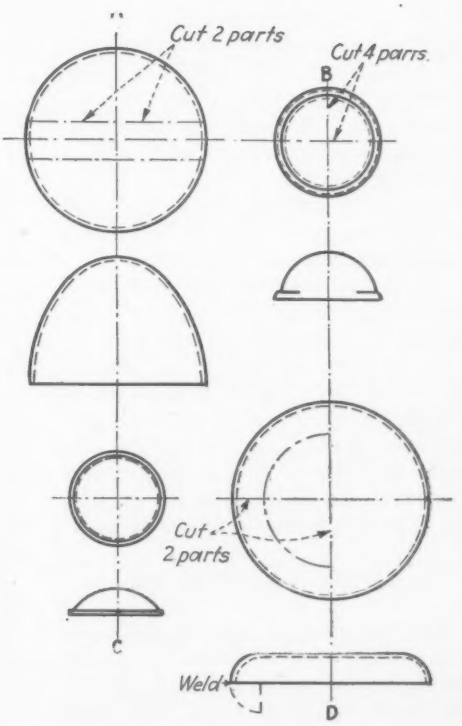




Spun sector patches butt-welded into body shell of tank truck for streamlining



Transmission housing for farm machine



Spinnings for redesigned power mower

Projection Methods For Reproducing Templates

THOMAS MILES
Reproduction Supervisor
Consolidated Vultee Aircraft Corporation

When and where to use methods involving cameras for reproducing templates are discussed in this second article of a series. Featured in this installment is a description of a vertical precision camera designed and built by the author.

THE projection method of reproducing templates generally makes use of the standard copy technique long used by photographers for making duplicates. However, certain refinements dictated by the need for accuracy, the handling of very large sheets and the reproduction onto metal instead of the conventional photographic printing paper are involved. Sensitized glass is usually used for making the negatives because of its exceptional dimensional stability, which is most important in obtaining accurate reproductions. These glass negatives will withstand almost any destructive influence except violent or careless handling. The camera used for reproducing templates is much larger than any found in commercial photographic studios.

The master layout is prepared on a sheet of aluminum or steel about 0.051 or 0.064 in. thick, which has been sprayed with several coats of fine-grained matte lacquer. The tint of this lacquer usually is off-white, slightly bluish or greenish to relieve strain on the eyes of draftsmen. Before any work is done on the sheet it is thoroughly sanded to a uniform satiny finish.

The lines are put on with a 4H or 5H pencil sharpened to a chisel point. In all reproduction work it is important to have a clean, dense line because the quality of the final print depends on the uniformity of graphite coverage over the area defined by the edges of the line. Differences in line density are shown in the illustration of segments of magnified lines on the facing page.

Operation of Camera

The camera is set up and calibrated to a standard set of reductions in size. Reductions of one-quarter and one-fifth are most widely used. A 30-in focal length lens covers a 5x10-ft. layout at one-fifth reduction. When all preparations for reproduction have been completed, the master layout is placed on a vacuum-frame easel.

Constant vacuum on the face of the easel holds the layout firmly in the flat plane of the easel face. A sensitized glass plate of appropriate size is placed in the negative holder, the master layout is illuminated and the lens cap removed for the exposure period. The glass plate is then removed to a dark room and developed in an extreme contrast developer such as D-85 or D-8, both of which are Eastman Kodak formulas, fixed in an acid-hardening bath, washed thoroughly and dried.

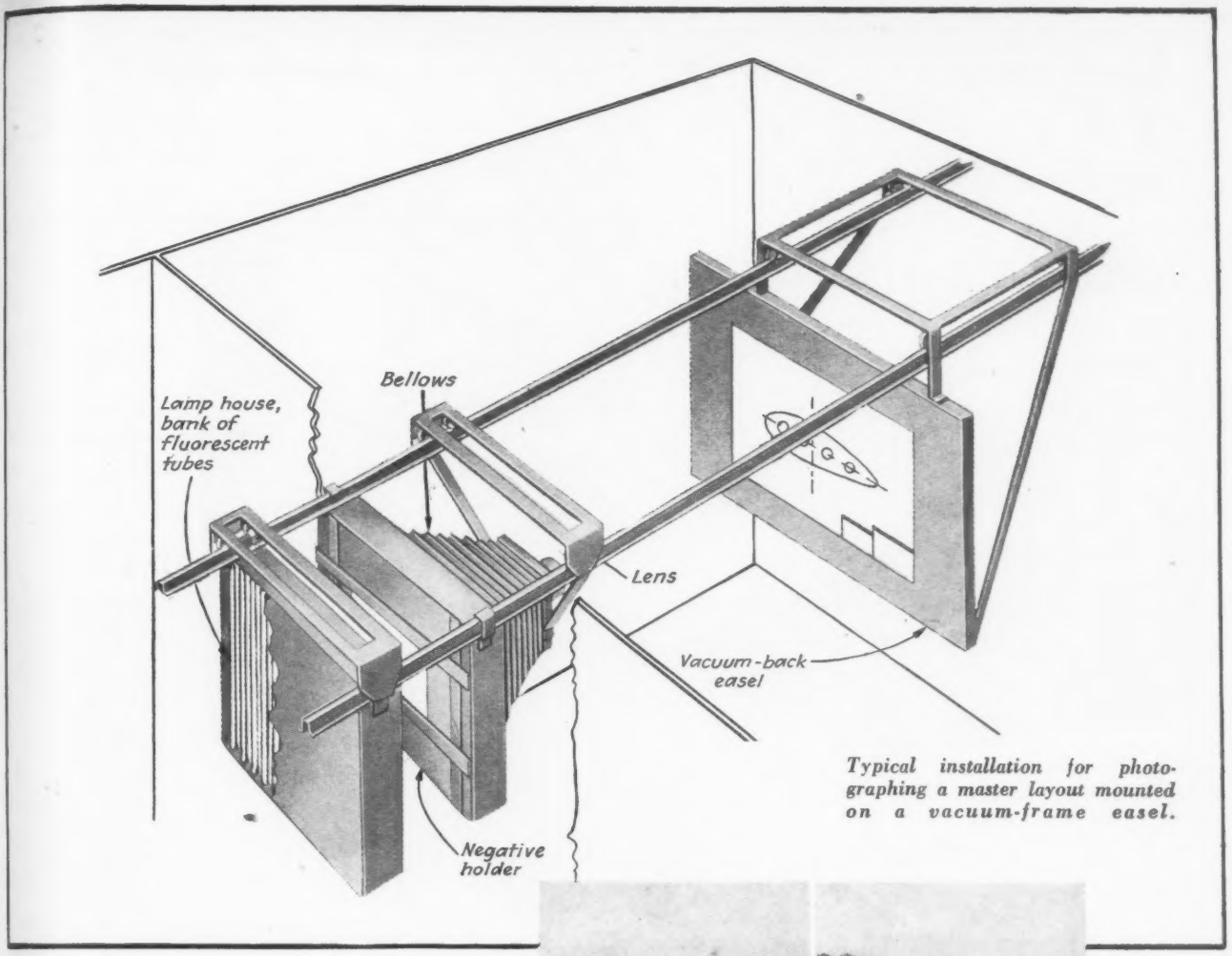
Most laboratories customarily use a potassium ferricyanide reducing solution, such as R-4a, to clean the image and reduce the line density locally to give a uniform density over the entire plate. This glass plate is a negative. After it is dried and retouched with an opaque to block out unwanted details and blemishes the negative is returned to the holder for projection to a positive reproduction of the original master layout. This is done by blacking out the easel of the camera, replacing the master layout with a sheet of photosensitive metal such as was described in the first article of this series, (PRODUCT ENGINEERING. Jan., 1943, p. 41) moving up the lamphouse behind the negative, turning on the light source and making the exposure as before by removing the lens cap. Difference in the thickness of the master layout and the sensitized sheet is compensated for by adjusting the easel. The latent image on the sensitized sheet is developed in an elon-hydroquinone developer, fixed, washed and dried.

The resultant print is checked against the master layout for dimensional fidelity. A trammel check is made along at least two sides of the reproduction to catch any distortional effects that may occur from the easel or negative holder being out of perpendicular with the optical axis, from an accidental error in resetting the easel or from a change in temperature affecting calibration of the camera. An error greater than that tolerated by drafting-room or template-department standards automatically scraps the print.

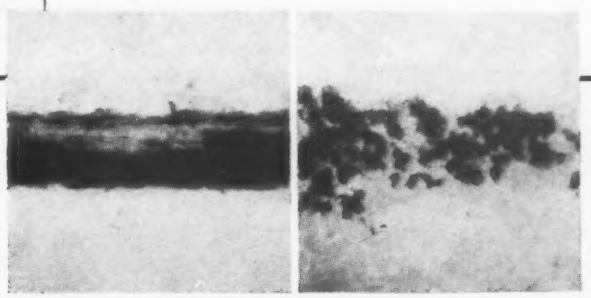
By the above procedure, reproductions can be made from a variety of layouts if necessary. Scribed lines on white- or greenish-lacquered metal can be made more distinct by washing the scribed sheet with a 10 percent solution of nitric acid, rinsing with water and then applying a solution of 5 percent copper sulphate and 5 percent nitric acid with a swab of cotton to the line areas, then washing and drying. The resultant deposit of brownish copper in the lines increases their contrast and kills reflectance from the bare metal. To increase the contrast of scribed lines on black-lacquered metal, cleaning the entire surface thoroughly and rolling with an inking roll covered with white printer's ink will produce dark lines on a white background. The copper treatment can be added to further define the lines. Lines scribed in wood can be brought out by the inking method.

Uses for Projection Method

The projection method is useful for making reduced-scale transparencies to cut down sizes of blueprints made from master layouts, thereby reducing blueprinting costs; making reduced-scale templates for wind-tunnel models or other testing purposes; and making increased-scale or "shrink" templates for alloy dies. Right-hand templates can be made by reversing the negative in its holder, provided the negative is made on a superior grade of plate glass to eliminate distortion from irregularities that may occur in the ordinary grade of sensitized plates on the market.



Typical installation for photographing a master layout mounted on a vacuum-frame easel.



Necessity for clean lines (left) on master layouts is emphasized by these magnified illustrations. Reproduction of the poor lines like those at right emphasizes irregularity and gives poor contrast.

An entire contour can therefore be developed from either half by matching the right-hand and left-hand images on a single print.

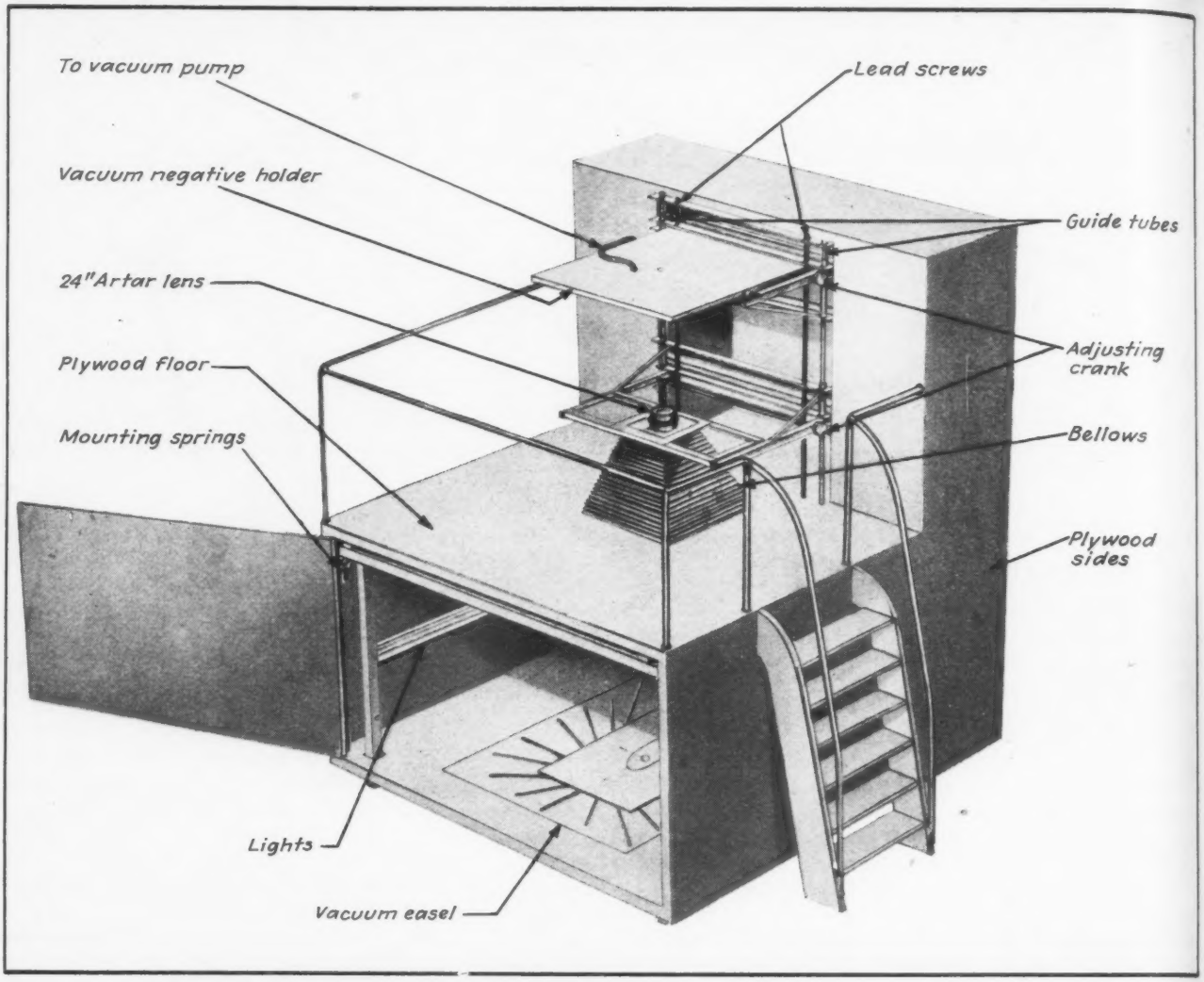
It is not practical to attempt quantity reproduction of lines onto a variety of materials having different thicknesses by the projection method. This is especially true when many different thicknesses are to be printed from a single negative because the precision changing of the easel requires considerable time that might be spent in making templates of these areas on a standard gage of template stock. Thus, the making of experimental parts and tooling, other than templates, is possible but inefficient if quantity reproduction is desired. These latter applications are best left to the contact methods of transfer, which will be described in subsequent articles of this series.

The equipment required to produce projection reproductions is quite expensive. The most important item is an efficient camera which will cost about $15,000 to $20,000. A good lens is an integral part of any camera and there is choice from a variety of formulas in the shorter focal lengths of 12 to 24 in. for small work. A focal-length lens of 70-in. is the longest readily obtainable at present.

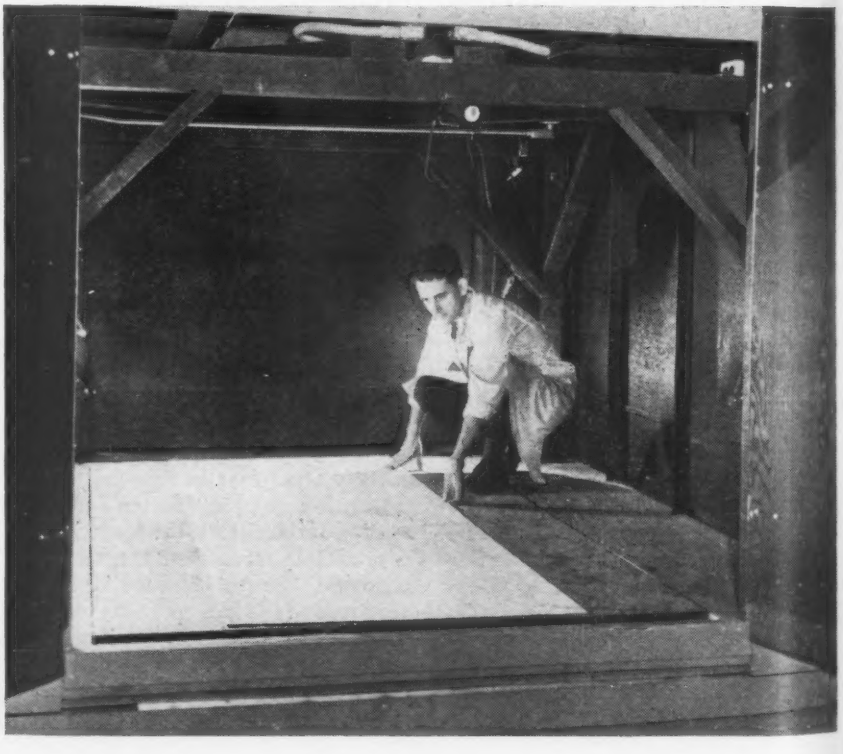
One objection raised in connection with the projection method has been the tendency for lines to widen when printed on a sensitized surface backed up with a white lacquer. This is because the halation or light that has passed through the emulsion and is reflected back from a white surface tends to spread and expose a larger area than it covers upon incidence with the emulsion surface. A good measure of this widening tendency is obtained by observing the junction of two lines crossing at a very small angle. If the lines tend to bleed together a considerable distance back from their actual crossing, it may be caused by over-exposure of the reproduction or too much halation from the base lacquer. Use of tinted-base lacquers and shorter exposure times remedy this difficulty. The projection method was first used by Glenn L. Martin Company and has since been adopted by Lockheed Aircraft Corporation, Douglas Aircraft Company, Boeing Aircraft Company and North American Aviation, Inc.

Vertical Precision Camera

A vertical camera was designed by the author and built by the Consolidated Vultee Aircraft Corporation to make reduced-scale transparencies from



Vertical precision camera, designed and built by the author, occupies a floor area 8 ft. square. (Below) In operating the camera layout is placed on the vacuum copy seal in the base of the assembly.



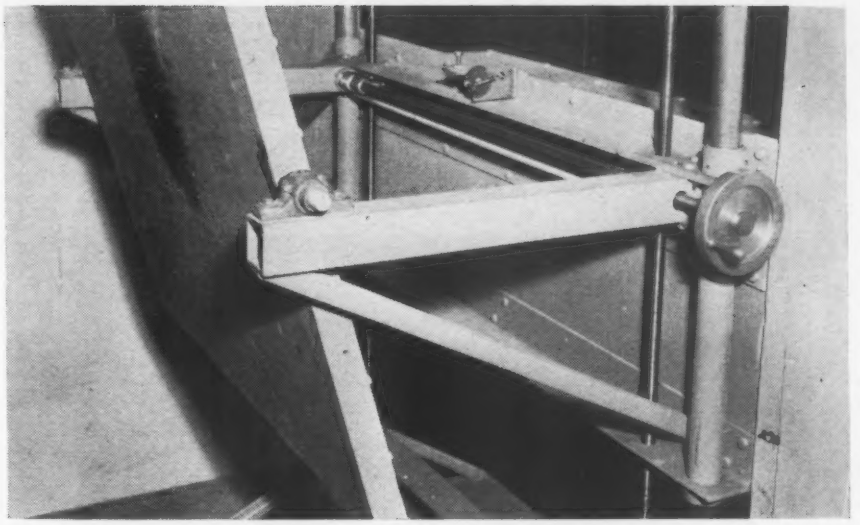
both fabrication layouts and master layouts. The conventional horizontal camera occupies much floor space, is expensive and is limited to sheet-stock copy, while the vertical camera is amply accurate, requires only an 8-ft. square area and can be operated in the regular template-reproduction darkroom without addition of walls. Another advantage is the direct reduction to required scale rather than making a greatly reduced negative and projecting back to the required scale.

Negatives Made on Vellum

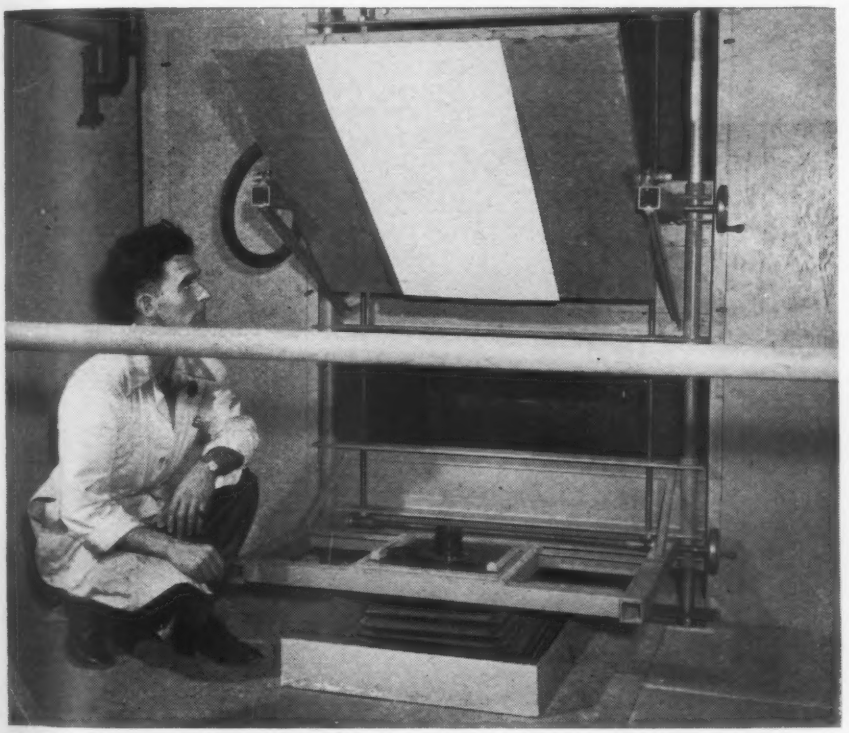
The negative is made on a sensitized waterproof vellum and processed. Positive prints are made on either transparent paper or linen. The area covered by the 24-in. Goerz Artar lens at one-half reduction is 48x60-in. Larger layouts are made in sections and the negatives spliced together before making contact prints. Prints are made from layouts up to 60x144 in. and no diffi-

culty has been experienced in matching the negatives.

The layout is placed on the vacuum copy easel and those 6-in. sections of the easel not covered are shut off by valves. Idler sheets are placed at either end of the layout to cover open holes, if the layout is not 90 in. long. The doors are closed, making contact with the limit switches which permits illumination of the copy lights. The operator steps onto the platform and swings the vacuum negative holder through approximately 150 deg. to facilitate placing the sensitized vellum. Any open areas on the easel are covered with thin paper to seal the vacuum system. The turbo-compressor is turned on, the negative easel turned back to a horizontal, face-down position where it is locked into register in the focal plane. The exposure of about 30 sec. at *f*.22 is made by switching on the lights or removing the lens cap.



Detail of the negative holder.



Sensitized vellum is placed in the vacuum negative holder. Exposure is made by either switching on the lights or removing the lens cap.

After exposure the vellum is passed to the processing tanks where it is rapidly developed, rinsed, fixed, washed and air-dried to prevent undue distortion from excess water absorption or heat. If the layout exceeds 48x60 in. the negatives are made with about 20 percent overlap and spliced in areas relatively clear of details. To make successive negatives, the layout is allowed to protrude from the front or back of the copy compartment by the felt covered slots in either end. As the negatives are made, the layout is pushed on through the other side. Two men, one on the platform and one changing the copy, can make a negative every 5 min. with ease.

The face of the vacuum copy easel is ¾-in. Masonite backed by 1½-in. spacers set every 6 in. and this is backed by ¾-in. plywood, the whole bolted to a cradle of angle iron which rests on the main camera frame on eight leveling screw points. This provides a flat easel and is easily corrected for level by the countersunk heads of the leveling screws. The entire 60x90-in. surface has No. 40 holes drilled on 1-in. centers.

The negative holder consists of two $\frac{3}{16}$-in. magnesium plates held together by bolts on 6-in. centers and 1½-in. bushings in the central area, with milled magnesium bars around the edge. The face plate has No. 40 holes on 1-in. centers and is finally surfaced by spraying on heavy surfacer and sanding until a flat surface is produced. The lightweight and rigid construction of the 37-in. square easel maintains a flat surface well.

The negative holder and lens holder are moved up and down on 1½-in. guide tubes by turning cranks. The shafts of these cranks mount worms which actuate worm gears threaded to the two vertical, stationary lead screws. The gear ratio is such that one turn of the crank moves the assembly through 0.01 in., permitting either the lens or negative holder to be set within 0.001 in. Counters on the shafts allow for resetting to any position without using scales with verniers. The entire optical system is suspended from an inside superstructure by coil springs, eliminating distortion from vibration. A bellows between the lens holder and the top of the copy compartment keeps stray light from striking the negative and flooding the darkroom.

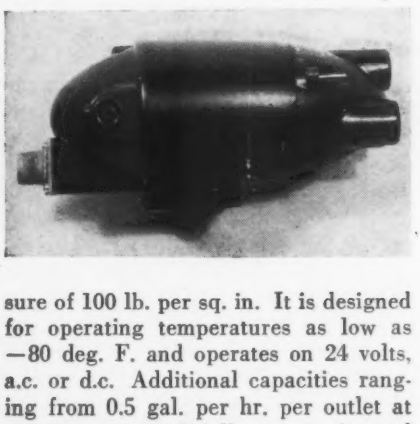
The vertical camera has numerous other copy uses, such as precision reduction of large proposed plant layouts; a lamp house with negative holder attached makes it possible to project up to any desired scale; by using different lenses photo-tracings can be made; and numerous other applications are cropping up every day.

EDITOR'S NOTE: The next article in this series will discuss primary-exposure methods using X-rays as a source of light for exposures.

NEW MATERIALS AND PARTS

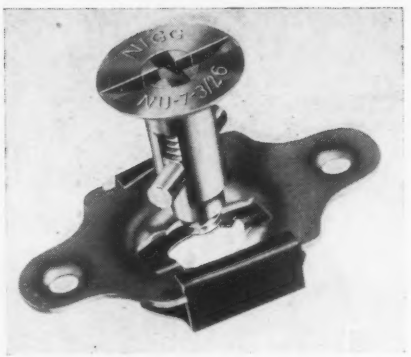
Fluid Metering Pump

Accurate metering of fluids from two discharge outlets is provided in the Series K pump developed especially for aircraft anti-icing systems for the protection of windshields, carburetors and propellers. It is also suitable for general industrial use in the pumping of light fluids at discharge pressures up to 150 lb. per sq. in. The pump is a direct-drive, rotary-vane type and conforms with the new AN envelope dimensions. It is available at present in capacities of 2.5 and 4.0 gal. per hr., dual outlet; and 5.0, 8.0, 15.0 and 30.0 gal. per hr., single outlet. These capacities are nominal values for a discharge pressure of 20 lb. per sq. in. and 3 in. mercury inlet suction head. The unit is capable of continuous operation at a discharge pressure of 100 lb. per sq. in. It is designed for operating temperatures as low as —80 deg. F. and operates on 24 volts, a.c. or d.c. Additional capacities ranging from 0.5 gal. per hr. per outlet at pressures up to 500 lb. per sq. in. and for operation at temperature ranges from —30 deg. F. to 300 deg. F. can be provided. Provision can also be made for operation at 6, 12, 100 and 220 volts, a.c. and d.c. The 2.5-gal. per hr. dual outlet, 24-volt, d.c. unit illustrated weighs 2.65 lb. Adel Precision Products Corp., Burbank, Calif.



All-Purpose Fastener

Developed to meet Army Air Forces Specification AN-F-8 and Air Service Command requirements a universal self-adjusting fastener locks and unlocks with a quarter turn. The fastener accommodates total sheet thicknesses from 0.025 to 0.260 in. Adjustment is controlled by a central screw which moves a sliding cross-pin sleeve through a range of 0.235 in. The adjustment is made from the outside to the desired tension and locking torque. In both tension and shear the fastener exceeds AN requirements. All outside requirements conform to standard dimensions, making the fastener replaceable with snap- or spring-type fasteners now in use. Also, existing receptacles can be utilized with the new stud assembly. Nigg Engineering Co., Covina, Calif.



Splashproof Motor

Vital parts of the Form J motor are protected from splashing by two-way ventilation which is now available in the 1½- to 15-hp. sizes. Cooling air is drawn in through baffle openings in the bottom of the end bracket by a fan on each end of the rotor, blown through and around all parts of the motor and out through louvered openings in the side of the frame and at the bottom. Century Electric Co., St. Louis 3, Mo.

Remote-Control Circuit Breaker

Operation and control of any remote electrical load is possible with the Klixon remote-control circuit breaker. These breaker-relays indicate circuit operation and can be reset from a control panel. The units are calibrated to precision tolerances and will carry at least 115 percent of rated current continuously, ultimately tripping at 125 percent of rated current in an ambient temperature of 77 deg. F. Actuating element is a snap-acting disk that is unaffected by vibration or shock. The breaker can be had for either trip-free or non-trip-free operation. In the former the breaker is free to open regardless of holding the handle in the closed position. In the latter the operator can override the action of the breaker from the control panel. These breakers are available in three frame sizes with current ratings from 35 to 200 amp. for circuits up to 30 volts, d.c., or 220 volts, a.c. Spencer Thermostat Co., Attleboro, Mass.

Belt-Driven Coolant Pump

Driven by a V-belt from a detached motor or drive shaft, the Model 1-P3 Gusher coolant pump has a one-piece shaft which revolves on two ball bearings mounted within the tubular section between the plate flange and the belt pulley. The pump stem, flange and im-

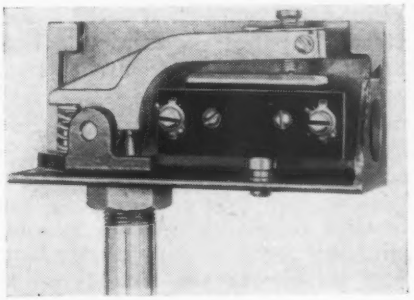
peller housing are interchangeable with the Gusher motor-driven Model 1-P3 pump and are likewise available in two lengths. The model incorporates the features of the Gusher pump line. Ruthman Machinery Co., 1818 Reading Rd., Cincinnati 2, Ohio.

Plywood Tubing

Made by wrapping layers of thin veneers bonded with thermosetting synthetic resins, Plytube ranges in size from ½ to 18 in. inside diameter with wall thicknesses from 0.05 to 0.50 in. Tolerances on inside diameters of comparatively small tubes are maintained at −0 in. and +0.01 in. Wall thicknesses are held to ± 0.005 in. These tubes have a specific gravity of less than 1.0 and tests show that they will carry a heavier load than steel tubing, weight for weight. Most applications so far have been in round tubing, although it is possible to fabricate straight and tapered tubes with various shaped cross-sections. Several formulations and constructions are available to take advantage of particular properties. Because of the synthetic-resin bonding agent the tubes are water-, flame-, splinter- and rust-resistant. They have low electrical conductivity and are dimensionally stable. The tubes can be cut with regular woodworking machinery and threaded with ordinary pipe dies. Products that have included Plytube as a more or less important part include sectional life raft oars, aircraft wings, parachute flare casings, motor shafts, radio antenna masts up to 90 ft., telescoping poles, and aircraft electrical conduits. Plymold Corp., Lawrence, Mass.

Temperature Limit Switch

Available with a reset button operated from outside of the case, Model H temperature limit switch can be had in several styles. One of these has the switch normally closed for cutting off heat, stopping a fan or closing a valve; another has the switch normally open for lighting a lamp or ringing a bell; and a third has a single-pole, double-throw switch that breaks the heating circuit while closing an alarm circuit. The range covered is from 0 to 1,400 deg. F. Dimensions are 5⅛ x 1¾ x 3 in. Burling Instrument Co., 253 Springfield Ave., Newark, N. J.

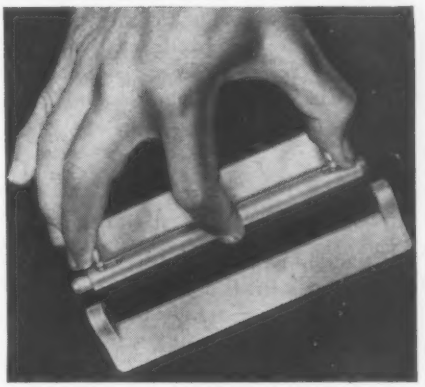


Anodic Treatment for Zinc

Applicable to any zinc-plated surface and in some cases to zinc-base die-castings, Anozinc is an electrolytic treatment that produces an anodic coating. This coating increases the corrosion resistance of, and inhibits the formation of white corrosion products on, zinc-coated steel parts. The coating is also an excellent base for subsequent organic coatings. Two finishes are now available. One is a dark, semi-lustrous black and the other is a brassy, slightly iridescent yellow. Parts finished in Anozinc baths have stood up in excess of 200 hr. under the Army-Navy salt spray test An-QQ-S-91. United Chromium, Inc., 51 East 42nd St., New York 17, N. Y.

Instant-Release Hinges

Made of a bracket that houses two spring-loaded attaching pins, a line of instant-release hinges is now available in complete sets where formerly only the male hinge was offered. These hinges are made of non-strategic material and have been used in such applications as ammunition chutes, map cases, tables and shelves, bulkheads and partitions, seats, cowlings, inspection plates, removable instrument panels and instruction boards, test equipment, scheduling boards and pilot curtains. In operation the pin at each end is retracted by finger pads which release the hinged part. Burklyn Co., 3429 Glendale Blvd., Los Angeles, Calif.



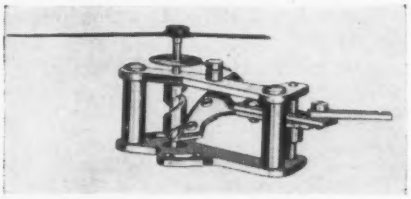
Vacuum Switches

Four new vacuum switches for a wide variety of radio and industrial switching applications have been announced. These units can be adapted to oil- or water-immersed operation because of their inclosed construction and are applicable for installation where fire and explosion are possible. Two of the switches are also designed for high-altitude application. The contacts are mounted in a vacuum and are relatively free from the effects of corrosion and arcing. The vacuum-type construction also gives the switches a high current

rating for their size and permits them to handle enough power to operate equipment at reduced voltages. No auxiliary contactors or relays are needed, and no self-contained coils or other operating mechanism is built into the switches. Movement is obtained from the mechanism to be controlled or from other apparatus to suit the application. A flexible diaphragm which transmits movement to the contact and acts as a natural fulcrum point for the operating arm eliminates the need for an external fulcrum. Net weight ranges from 1 to 2 oz. Electronics Dept., General Electric Co., Schenectady, N. Y.

Cam-and-Roller Movement

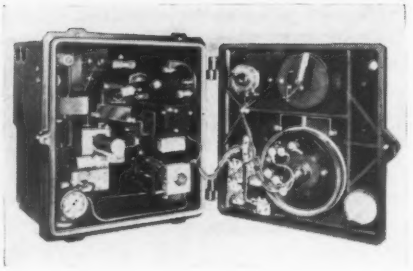
Principal part of a patented cam-and-roller movement is a sector-shaped driving cam and a driven helical roller, developed especially for use in pressure-indicating gages. One end of the pivoted cam is linked to the tip of a Bourdon tube, while the other end is aligned with and fits freely into the thread of the roller. A hair-spring limits the point of contact between the cam and roller to one side of the element and prevents



backlash. Overstretch or collapse of the Bourdon tube cannot jam the internal mechanism. The driving cam has a plastic facing material and the ball-shaped roller pivot rides on a bearing of dissimilar metal. Certified Gauge & Instrument Corp., 34–18 Northern Blvd., Long Island City, N. Y.

Electronic Controller

No continuously moving parts are used in the Celectray electronic pneumatic indicating controller. In this instrument the original Celectray controller, which has a mirror galvonometer and photoelectric amplifier, is combined with a pneumatic follower. Output air is precisely controlled. On-and-off or open-and-shut control is available in two models—high sensitivity, non-adjustable throttling or on-and-off without throttling. A magnetic air valve which acts as an amplifier and converter from electric to pneumatic operation replaces the relay valve in the standard Celectray controller. The light beam "follow-up" flag is moved back and forth by changes



of air pressure in the bellows of the "follow-up" assembly unless the adjusting arm is turned to the highest sensitivity on its scale. More light on the phototube causes more current to flow through the magnetic air valve which, in turn, draws in the armature, moving the orifice tongue closer to the orifice in the block and raising the controlled air pressure. Less light on the phototube lowers the controlled air pressure by decreasing the current to the magnetic air valve. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

Alkali Steel Cleaner

Developed for cleaning steel, an alkali material called Cleaner 100 is said to have excellent rinsability and long life. It is used in a concentration from 4 to 8 oz. per gal. in the temperature range from 180 to 212 deg. F. It is best used anodically, but is also effective as an immersion cleaner. Cleaner 100 contains no soap such as rosin soap, but contains complex phosphates to solubilize any fatty acid soap that may form from greases and oils. The cleaner is effective in soft and very hard water and does not form insoluble residues. Enthone Co., 442 Elm St., New Haven, Conn.

Porcelain-Clad Capacitors

For high voltage d.c. applications where space is limited, solder-sealed porcelain-clad type FPC Inerteen capacitors have been announced. From 7,500 up to and including 200,000 volts

the capacitor elements are hermetically sealed in a tubular wet-process porcelain body with solder-sealed enclosures. These enclosures act as the capacitor terminals by connecting the element leads at opposite ends, utilizing the porcelain tube as insulation. This eliminates a metal case and bushings. Larger types are furnished with or without cast mounting flanges. Where these castings are used the capacitors are solder-sealed and the castings are cemented on with mineral glass compound. Dept. 7-N-20, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Midget Air Control Valve

Operation at sustained speeds as high as 400 reversals per min. is a feature of a compact, solenoid-operated, air control valve known as Model No. 835. It is a ¼-in. heavy-duty, 4-way valve for the control of double-acting cylinders. It can also be used as a 3-way valve by plugging one outlet. Over-all dimensions are 7 in. long, 3½ in. wide and 5¼ in. high. Ross Operating Valve Co., 6495 Epworth Blvd., Detroit 10, Mich.

Chemical Stoneware

Discovery of a method for reducing the bond of high silica and alkali common to clay bodies has led to the development of Ceratherm 500, a low-porosity chemical stoneware that can be directly heated by steam or hot gases and cooled quickly. The material increases in strength when heated to 400 deg. F. and quenched and shows no loss of strength after repeated heating to this temperature and cooling. It is used for such items as tanks, crocks, boiling kettles, mixing kettles, cooling and condensing coils, evaporating dishes, pumps, sinks and pipes. U. S. Stoneware Co., Akron, Ohio.

Free Enterprise

. . . INCENTIVES AND TAXATION

There are three principal ways of making a living:

1. Getting on someone's payroll
2. Lending one's savings to business enterprises
3. Starting, or helping to start, a business enterprise

About three out of four of us fall in the first group—we are ***job-holders.*** Millions of us get some income, large or small, by lending our savings—directly or through such channels as insurance companies. We are suppliers of ***loan-capital.*** About one out of four of us has his own business enterprise, and several millions of us are part owners of business enterprises. Those of us who go into business for ourselves and those of us who are part owners of enterprises are ***job-givers.***

The amount of employment in a community depends, in the main, on the number of persons who attempt to make their living, or part of their living, by giving jobs to others, rather than by getting on someone's payroll. A community seriously desiring a high level of employment and a high standard of living will strive to make job-giving attractive and to encourage a large part of its population to be job-givers rather than merely job-holders.

The number of men who attempt to make their living in whole or in part by starting new businesses or by expanding old ones depends upon the outlook for profits. When the outlook for profits improves, thousands of new jobs open up and thousands of men go to work; and, as men go to work, the farmer and everybody else benefits. When the prospect for profits becomes darker, the demand for labor, capital, and raw materials drops. It may be roughly estimated that an improvement in the prospect for profits of one billion dollars raises the demand for labor by anywhere from two billion dollars to five billion dollars.

One of the principal determinants of the outlook for profits is the amount and the nature of taxes. After the war, the Federal government will need to raise each year about twenty billion dollars in taxes—three times the amount required before the war, and six times the amount re-

quired in the Twenties. In the Twenties, the tax needs of the Federal government were roughly twice as large as corporate profits in a good year. After the war, Federal revenue needs will be roughly three times corporate profits in a good year. Obviously, it will be much more difficult, after the war, for the government to meet its needs *without discouraging enterprise,* and therefore without diminishing the number of jobs, than it was before the war. Far more than ever before, it will be necessary for the government in developing a tax program to take account of the effect of taxes upon employment and the standard of living. This means that it will be important for each and every citizen to give attention to these matters—because the policies of the government reflect, in the main, the thinking of the citizens.

Some taxes seriously discourage individuals and business firms from undertaking new and enlarged operations. Other taxes have little or no adverse effect on investments. Some taxes are a burden on consumption, affecting the sales of specific commodities, depending on the nature of the taxes. It is obvious that different kinds of taxes have different economic influences. *We must understand the forces that determine the level of employment and consider the tax program in relation to other measures designed to create more jobs.*

What are the tests of a good tax system?

1. Taxes should be designed to encourage production and enterprise and to make it attractive for a large number of people to earn all or part of their living by giving jobs to others.

2. Taxation must be fair in principle and administration, with no discrimination between persons in similar circumstances.

3. Taxes should be apparent and not concealed, and should be levied, in the main, directly upon individuals so that each of us will know how much our government is costing him. A moderate income tax at the lower income levels will bring a greater awareness of responsibility than will heavy taxes on consumption which the taxpayer does not see because they are hidden in the prices he pays.

4. In the aggregate, taxes should be somewhat progressive.

5. The tax system should be coordinated with the broader objectives of monetary and fiscal policy.

6. **Federal, state, and local tax policies should be integrated as to principles and objectives.**

Judged by these standards, our present tax system is extremely unsatisfactory; in fact, it is actually damaging. It is a conglomeration of hidden and direct taxes and of conflicting taxing jurisdictions and policies, with no comprehensive economic motive. It is distorted to appease pressure groups and includes uneconomic punitive measures. It is full of needless complexities. It is a paradise for tax lawyers and a source of confusion and despair for the honest, enterprising business man. In fact, it would seem almost as if our tax laws had been written by some fifth columnist for the purpose of making private enterprise unworkable. We in America pretend to believe in the pioneer spirit, but no one would ever suspect it by looking at our tax system.

When the war is over, there must be a thorough reform of our entire tax system. Federal taxes can and should be reduced substantially; and, in the process of reduction, changes can more readily be introduced. At that time, steps can be taken to achieve some degree of coordination and unity of purpose among federal, state, and local taxing agencies. Taxes play too important a role in our total economic life to ignore the adverse consequences of unrelated and inconsistent policies of different taxing jurisdictions.

The following reform measures are needed in federal taxation:

1. **Repeal of the excess profits tax at the earliest possible date after inflationary dangers subside. In the case of most enterprises, the excess profits tax destroys all incentive to do a larger volume of business than in 1939; it appropriates virtually all increase in profits above the level of 1939.**

2. **Coordinate corporation and individual income taxes so as to avoid double taxation and impediments to risk-taking. Preferably, corporation income taxes should be wholly eliminated. Otherwise, the corporation tax rates should be reduced to the lowest effective rate on personal incomes. Full credit should be given to stockholders for all corporate income taxes paid.**

3. **Encourage competition and particularly the formation of new enterprises by allowing new corporations generous tax exemptions for a period of five years. Extend the same principle to unincorporated concerns.**

4. **Encourage risk-taking (and hence job-**

giving) through extending the loss carry-over to six years or more.

5. Provide for averaging incomes over a period of years in order to remove discrimination against those with irregular incomes and those who take risks of loss in business ventures.

6. Rely upon the personal income tax as the main source of revenue, with broad coverage. The reduction in total taxes after the war should favor the elimination of excise taxes before reducing income taxes.

7. Reduce the upper range of personal income tax rates to a maximum of perhaps fifty to sixty per cent so that risk-taking investments will be really attractive. Higher rates are punitive in character, yield small receipts, and throttle risk-taking.

8. Encourage risk-taking by individuals in the higher brackets by making the surtax on incomes of $20,000 a year or more half as much on income in the form of dividends as on income in the form of salaries or interest.

9. Encourage risk-taking by individuals by permitting capital losses to be charged against general income provided the reduction of tax liability in any one year is not more than fifty per cent.

10. Repeal the tax-exempt privilege for all *new* securities issued by all governmental jurisdictions.

11. Eliminate excise taxes which place a disproportionate burden on persons with lower incomes so as to encourage greater consumption and provide an expanded market for our vast industrial capacity.

12. Reform tax administration to simplify forms and procedures, to broaden the scope of enforcement, and to encourage the spirit of fairness.

With such reforms and continuing reappraisal of the tax program as it affects the economic situation, we can look toward taxation as an instrument of constructive influence in giving the fullest encouragement to free enterprise and in attaining continued prosperity.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

INDUSTRY AND SOCIETIES

NEWS • READER LETTERS • MEETINGS

Development of Post-War Private Airplane Leaves Much Work for Designers

MUCH WORK on the part of designers will be necessary for the development of satisfactory post-war private airplanes according to William D. Hall, chief engineer, Aeronca Aircraft Corporation, in an address at the recent war engineering annual meeting of the Society of Automotive Engineers in Detroit.

There will be at least three types of private airplanes offered to the public, Mr. Hall indicated. These are a training-type craft, with either tandem or side-by-side seating, which will consist of the minimum amount of aircraft structure that will fly satisfactorily, will be a refined version of the pre-war light airplane models and will sell at approximately $1,000; a medium-performance type aircraft that will be super-safe and will be available in 2-, 4- or 5-place models ranging in price from approximately $1,500 to about $3,000; and a $2,000-class airplane that will provide the maximum performance consistent with reasonable safety, comfort and cost.

The ideal airplane will be the best compromise between safety, cost, performance, dependability and comfort for the purose for which it is intended. The type of airplane, however, that automatically keeps the operator out of trouble is Utopian and therefore is the one to strive for, although it possibly never will be completely reached.

Non-spinning characteristics will probably be accomplished as they were in the past. Combined rudder and aileron control will most likely be incorporated at the expense of some maneuverability. Accessories will be used where occasion demands and will be automatic in operation wherever possible. Tricycle landing gears will become popular. Navigation will be considerably simplified and the bad effects of weather minimized by the use of existing accessories and other developments still unknown.

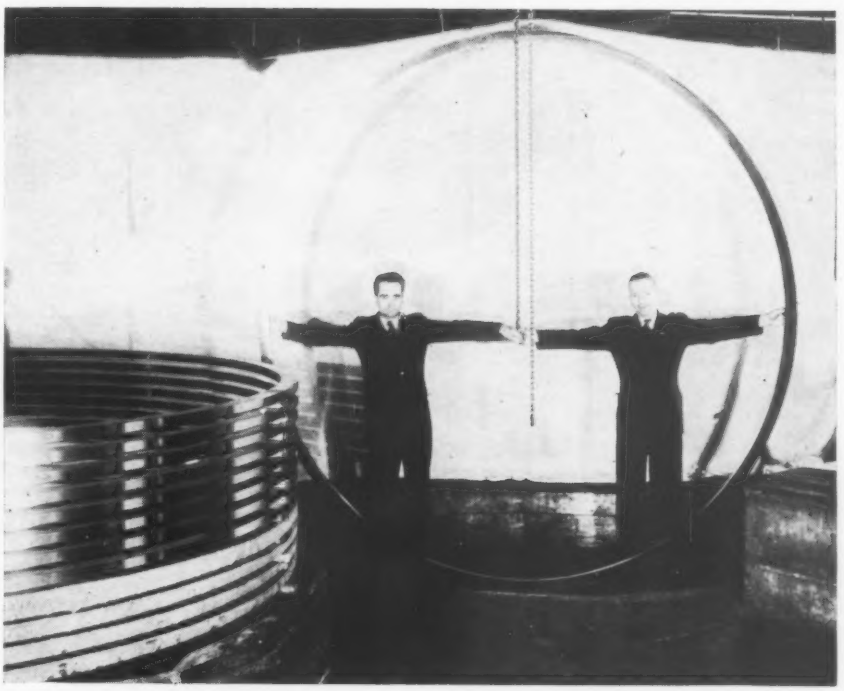
Aircraft models will be carried over from year-to-year, with minor changes, to amortize the high development and tooling costs. Operating costs will be cut by building the structure of the planes entirely of metal and substituting more durable materials than those formerly used for non-structural parts and equipment.

More engineering work than has been done in the past will be required to develop units that are more comfortable, smoother, quieter and have more efficient structures. The basic structure of pre-war aircraft was satisfactory, the main troubles coming from accessory items. Experience gained during the war in developing such accessories to withstand extreme conditions will help to eliminate most of the pre-war difficulties. Thorough studies in exhaust muffling, vibration, sound-proofing, air-conditioning and seat construction will lead to greater comfort.

C.E.D. Program for 1944 Described by Fletcher

OUTSTANDING EXPERTS in manufacturing, marketing, sales, finance, management and engineering have organized to make available to American business during

Close Tolerances on 10-ft. Bearing Races



Anti-friction bearings 10 ft. in diameter are being made by the Bantam Bearings Div. of the Torrington Co., for the 5-in./38 cal. twin anti-aircraft gun mount used by the Navy. These bearing races are machined and ground to limits within 0.002 in. in diameter, and 0.001 in. in parallel. The races and rollers are chrome-plated to conform to U. S. Navy standards for gun-mount bearings of this type.

1944 the latest practical knowledge needed to help them effect an expansion of post-war production and employment to unprecedented peacetime levels, Marion B. Folsom, chairman of the Field Development Division of the Committee for Economic Development announced at the end of last year. Eleven action and advisory committees will make this knowledge freely available to all American businessmen in publications and by consultation.

"The most pressing job of the C.E.D. in 1943," said C. Scott Fletcher, director of the Field Development Division, "was to organize businessmen at the community level to study conditions in their own localities and in their own businesses and to take responsibility for devising the bold plans for reducing post-war unemployment to the bedrock minimum. Today, we have more than 1,300 regional, state, district and community committees.

"In 1944 the C.E.D.'s most urgent task will be to make available to the nation's 2,000,000 business employers the best American managerial science, imagination and know-how in such practical form that it can be applied effectively to their own post-war planning problems. Our Research Division advises us that 55,000,000 post-war civilian jobs in business, agriculture and government producing $142,000,000,000 of goods and services is a reasonable and achievable goal."

C.E.D.'s new program is based on the fact that there are six major functions or aspects of post-war planning to be undertaken by an industrial or manufacturing firm. These are organization of the firm's over-all planning program, including the defining and placing of responsibility in such a way that it will not interfere with war work; analysis of products, their redesign or the addition of new products; analysis of markets, and the planning of sales and advertising programs; planning for production facilities required to produce expanded post-war volume; estimate of number of employees needed for expanded post-war volume and the necessary employee-training program; and analysis of financial requirements for reconversion and expansion for post-war business.

The advisory committee formed from the country's leading experts in each of these fields will make available specialized knowledge to help business, particularly the medium-sized to smaller firms employing 100 or more persons, to tackle the job of planning. This material will be passed through the community committees to individual firms.

In addition to their advisory function, a number of these committees are engaging in an action program to stimulate various sections of business through national channels.

The New Materials, Processes and Designs Committee, which is of particular interest to mechanical designers and of which George F. Nordenholt, editor of PRODUCT ENGINEERING, is chairman, is preparing important facts about new materials and processes to stimulate manufacturers to make goods that will look better, work better and sell for less. How designers can benefit through C.E.D. activities was described in detail in PRODUCT ENGINEERING for Sept. 1943, p. 539. The material that the committee is gathering will be presented in a booklet and some of it in sound slide-film, and will soon be available through local C.E.D. committees.

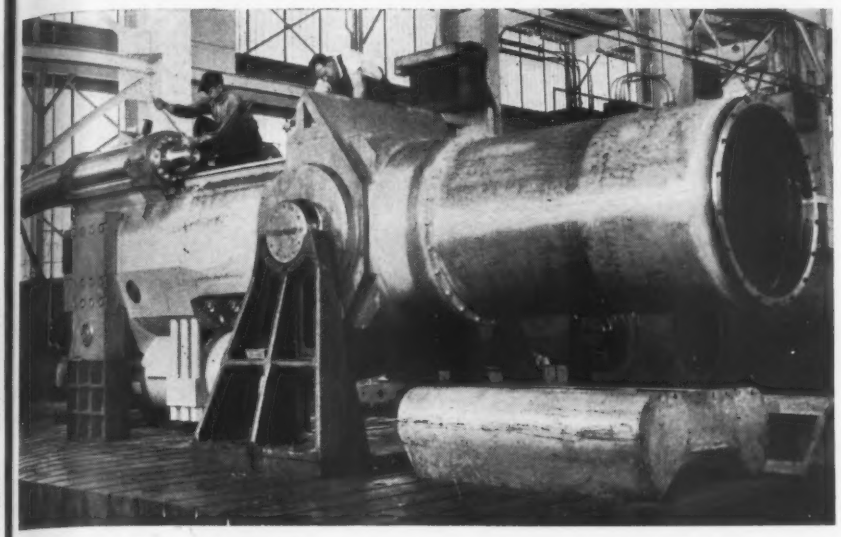
Molded Parts of Polyvinyl Alcohol

Compar is the name given by the Resistoflex Corporation to its modified polyvinyl alcohol resin which in many respects has properties entirely unlike the original resins. Various formulations are available for specific applications. The material can be extruded or molded, or is available in sheet form or in solution. Its outstanding characteristic is inertness to organic solvents. Other notable characteristics are flexibility, toughness and abrasion resistance. Molded products are characterized by tensile strength, inertness to fuels, oils and other organic solvents, imperviousness to gases, and resistance to abrasion, impact, vibration, aging and flexing.

Tank Firing Mechanism May Stabilize Vehicles

PRINCIPLES of the servo-mechanism, tha enable American tanks to fire on th run with devastating effect, will likel provide "floating" rides in high-spee trains and other vehicles, according t Westinghouse Electric & Manufactur ing Company engineers. Developmen work on these applications already ha been started. Calculations show that th power required to stabilize the vertic movement of either a railroad coach o an automobile is only about 3 hp. Th is because the equipment and power re quired depend on the weight of the ob ject multiplied by the square of th vertical movement.

Recoil Housing Machined to 0.003-in. Tolerances



Nearly ready for service on a battleship, this 25-ton mass of precision-finished steel, used for the stationary housing for the recoil mechanism of a 16-in. gun, is being given a final check at the Naval Ordnance plant operated by Westinghouse Electric & Manufacturing Company at Louisville, Ky. Machining tolerances of 0.003 in. are maintained in some places in this forging.

Discussions and Comments From Readers

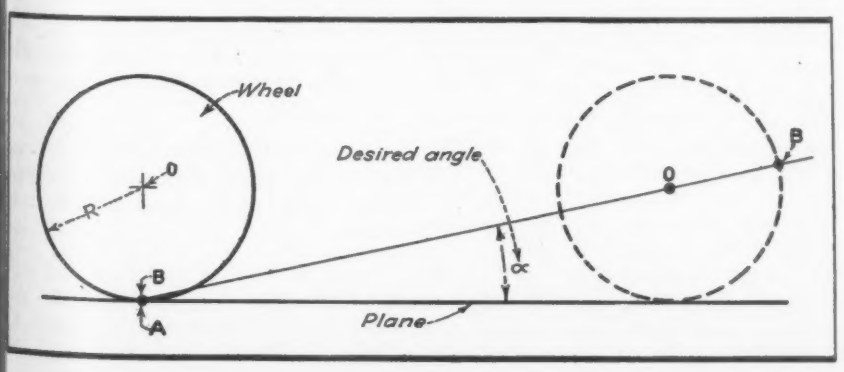
FIND THE PASSWORD BY SOLVING THE PROBLEM

To the Editor:

I wonder how many of your loyal army of readers would like to join an ancient secret mathematical society. As the story goes, an ancient society of mathematicians had a certain number for a password. In order to qualify for membership each candidate had to obtain this secret number by solving a problem. The secret number is the number of radians in the angle in the following problem:

The initial position of a wheel in contact with a plane is shown by full lines in the figure. Point *A* on the plane is in contact with point *B* on the wheel. The wheel is rolled without slipping on the plane until point *B* on the wheel, center *O* of the wheel and point *A* on the plane are in a straight line. The problem is to find the number of radians in the angle that this straight line makes with the plane.

—Reinie Arner
Highspire, Pa.



DECEMBER EDITORIAL GAINS HIGH PRAISE

To the Editor:

Congratulations for your editorial on industrial designers (Product Engineering, Dec., 1943, p. 773) which is the most constructive criticism of our profession that has ever come to us from any magazine. Only a good friend to our struggling cause would come out with the honesty, sincerity and truth of your statements, because it is a truism that only our best friends will take the time and trouble to labor over our faults.

To those of us who have come by our laurels the hard way by diligence, honesty and patience; to those of us who have won the respect of our clients for jobs well done; to those of us who are acquiring a better understanding of the foundation structure of our profession; your editorial makes us pause for thought.

Until you came along the American Designers' Institute was the only sanctuary we poor designers had. There, by a wailing wall created sometimes by this and sometimes by that, we beat our breasts over the sorrows of our profession. Sometimes the tail wagged the dog, but this happens in all young and growing organizations. At the present time, right or wrong, the A.D.I. is the only national organization of industrial designers in the country. It is incorporated in Illinois, has by-laws, code of ethics, standards of practice and the agenda calls for another crack at contractual practice between buyer and seller. State licensing, too, is on the agenda. Our members are not snobbish and are made up of top notch designers across the country. We have egos that sometimes get too big for our hats, but who can blame the healthy spirit that prompts us to feel that only "thee and me are perfect and sometimes thee seems a little strange."

We need help, encouragement and new members because we need lots of workers on the committees assigned to the many tasks before us. We need recognition as able performers in the industrial world, and not as screwballs. That is why I liked your editorial. You touched on so many vital points that I am sure you can be quite a help to the A.D.I. and industrial design, generally, through the readership of your publication. Thanks for the honesty of your criticism. —William O'Neil

To the Editor:

Your editorial in Product Engineering should be read by every designer as it enumerates so clearly the responsibilities of every individual person in our profession. The American Designers' Institute is appreciative of all constructive criticism and your thoughts will be extremely helpful in adjusting our policies and future plans.

In your article you mentioned the advisability of a code of ethics. At the founding of the American Designers' Institute we set up a code of ethics. This code has since been reviewed and changed and it is probably our fault that some of these principles are not publicized and are unknown to many people.

As the American Designers' Institute

is a very young organization compared with others and as our aims are so broad, it will take considerable time to have the organization functioning as clearly as other professional institutes. We do have a very active New York Chapter and would consider it a great step forward if we could count on your cooperation with this group to accomplish the high type of organization all of us hope for.

—ALFONS BACH, *President*
American Designers' Institute

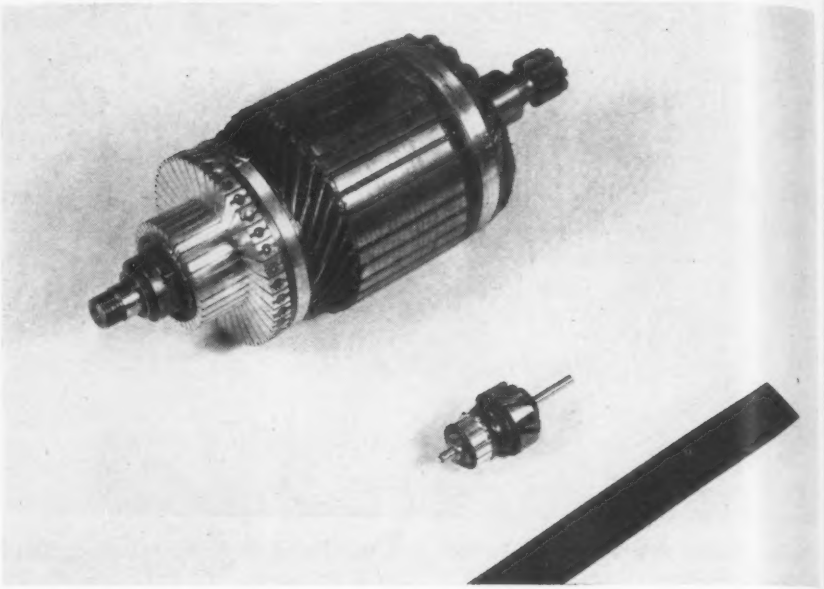
To the Editor:

I have just read your editorial in the December issue of PRODUCT ENGINEERING, and may I say that I heartily concur in everything you said. I agree that the ADI has probably made the most sincere attempt to organize along these lines but, frankly, I have been unable to determine just what their main objective is.

It is my opinion that over the past 15 years many men have hung out their shingles, as you describe it, who have been sadly lacking in the necessary qualifications. It does seem too bad that enough of us can't get together to form the nucleus of an organization which would operate along the lines you suggest, and it might not be out of place for me to suggest that with your acquaintanceship and contacts throughout the country you might logically be the one to send out feelers to various designers and get their reaction. I for one would most heartily subscribe to and endorse such a movement and I still feel that the missionary work would accomplish more if carried out by someone like yourself who has no "bone to pick." In the meantime, more power to you and three rousing cheers.

—D. L. HADLEY, *Design Consultant*
Westinghouse Electric & Mfg. Co.

Big and Little Aircraft Motor Armatures



Of the various sizes of armatures produced by the Eureka Vacuum Cleaner Company for electric motors used to operate a variety of equipment in military aircraft those shown here represent the largest and smallest. The large armature, used in an engine starter motor, weighs 5⅓ lb. and is wound with copper wire capable of handling a maximum current of 150 amp. The small armature, weighing 1.5 oz. and operating on 0.3 amp., is used in the motor which operates aircraft machine gun sights and is wound with copper wire about twice the diameter of human hair.

Activities Among Technical Societies

PLASTIC MOLDING POWDERS MADE FROM WOOD WASTE

How waste products from the manufacture of lumber might be used to make plastic molding powders was described by Robert A. Hardin, chairman, Engineering Shop, University of Oklahoma, at a recent meeting of the Oklahoma Planning and Resources Board. It was pointed out that 76 percent of wood is lost before it is used. Much of this waste, according to Mr. Hardin, could be used to advantage by setting up wood-hydrolyzing plants at points where lumber is manufactured. These plants could extract the lignocellulose from the waste sawdust and other material, and the lignocellulose can then be combined with various plastic resins to form plastic molding powders. Use of hydrolyzed wood as a filler for plastic resins might reduce the necessary amount of resin in the combined material by 50 percent.

Experiments have been carried out at the University of Oklahoma dealing with the manufacture of a plastic molding compound from Oklahoma yellow pine wood waste. Plastic molding compounds have been made with the following resins, and resulting in the following tensile strength ranges: Phenolic resin, 4,000 to 11,000 lb. per sq. in.; urea formaldehyde resin, 5,000 to 12,000 lb. per sq. in.; vinyl chloride resin, 8,000 to 10,000 lb. per sq. in.; and methyl methacrylate resin, 4,000 to 7,000 lb. per sq. in. The color of plastics made from these materials is limited to black.

Do You Know That—

SLIGHTLY LESS THAN 5,250,000,000 board feet of lumber and nearly 500,000,000 sq. ft. of plywood have been used to replace 5,297,076 tons of metal, with the largest items of replacement being in the construction of ships and boats. (5)

A DEVICE SENSITIVE enough to record full scale one millionth of a millionth of a watt of electrical power has been developed. (6)

WOOD CELLULOSE is the most abundant organic raw material in the world. (7)

AN ALLOY of 98 percent copper and 2 percent beryllium is harder than structural steel. (8)

TEN THOUSAND FEET of glue-laminated Douglas fir plywood are used in every Liberty ship. (9)

CELLULAR HARD RUBBER buoyancy units made from reclaimed rubber are replacing copper tanks previously used in small boats. (10)

WHEN PLYWOOD IS EMBOSSED such high pressures are developed that the plywood is crushed to about one-half its original volume. (11)

Manufacturers' Publications

Porous Metal—Moraine Products Div., General Motors Corp., Dayton, Ohio. Booklet, 68 pages. Describes Porex, a porous-metal product of powder metallurgy, illustrates its application as a medium for filtration, separation, diffusion, flow control and other functions and tells how to adapt Porex to particular requirements, all of which is supplemented with numerous tables, charts and other engineering data useful to designers.

Plastics—Panelyte Div., St. Regis Paper Co., 230 Park Ave., New York, N. Y. Data book, 54 pages. Consists of a collection of engineering bulletins, each describing a particular grade of a paper-, fabric- or asbestos-base plastic material all of which are manufactured in sheets, rods, tubes, molded forms and fabricated parts.

Aircraft Tubing — Tubing Seal-Cap, Inc., 215 W. Seventh St., Los Angeles, Calif. Manual, 32 pages. Contains much technical information on the handling and installation of tubing in aircraft and describes many types of caps for sealing the ends of tubes.

Alloy Powders—Metal Alloys Div., Unexcelled Mfg. Co., 11 Park Place, New York 7, N. Y. Bulletin, 4 pages. Lists various alloy powders available for use in the production of powdered-metal parts and illustrates some of the parts that can be made by this method.

Induction Hardening—Tocco Div., Ohio Crankshaft Co., 3800 Harvard Ave., Cleveland 1, Ohio. Booklet No. 15, 32 pages. This revision of a description of the Tocco induction-hardening process covers the process completely and presents up-to-date information regarding what can be done with it.

Cleaning—Dept. PE, Enthone Co., 442 Elm St., New Haven, Conn. Bulletin, 4 pages. Describes Cleaner 100, a new alkaline cleaning material for steel that can be used in either immersion or electrolytic baths.

Flow Meters—Cochrane Corp., 17th St. and Allegheny Ave., Philadelphia 32, Pa. Reprint No. 29, 16 pages. Consists of several reprints of articles on "Flow-Meter Engineering" plus several pages of additional engineering information.

Gages—Certified Gauge & Instrument Corp., 34-18 Northern Blvd., Long Island City, N. Y. Bulletin, 12 pages. Describes various types of pressure, vacuum and compound gages featuring a patented cam-and-roller movement.

Clutches — Hilliard Corp., 101 W. Fourth St., Elmira, N. Y. Four bulletins, 4 pages each. Operation, mechanical details and typical applications of friction, centrifugal, single-revolution and overrunning clutches are presented in concise form.

Speed Reducer — Stephens-Adamson Mfg. Co., Aurora, Ill. Catalog No. 643, 12 pages. Gives details of Saco single- and double-reduction type gear reducers, including how to select the proper type and size.

Solenoid—John S. Barnes Corp., Rockford, Ill. Bulletin, 2 pages. Contains complete description of a midget solenoid, with engineering data and performance data included.

Generators—General Electric Co., Schenectady, N. Y. Bulletin GEA-1607-D, 4 pages. Highlights principle features of Type B and Type CD direct-current generators, which can also be used as exciters.

Pilot Lights—Dial Light Co. of America, 90 West St., New York 6, N. Y. Catalog No. 43, 24 pages. Describes and illustrates pilot lights and assemblies for various applications.

Carbon—National Carbon Co., P. O. Box 6087, Cleveland 1, Ohio. Catalog section M-8000, 16 pages. Covers characteristics and properties of carbon and graphite products and describes and illustrates various industrial applications of these materials.

Fasteners — Tinnerman Products, Inc., 2038 Fulton Rd., Cleveland, Ohio. Catalog No. 185, 24 pages. Explains the Speed-Nut principle and shows many of its applications under widely varying conditions.

Bearings—Bound Brook Oil-less Bearing Co., Bound Brook, N. J. Stock List No. 2, 16 pages. Many heretofore unpublicized sizes and shapes of Compo oil-retaining bronze bearings are featured with essential information on the material itself.

Valves — R-S Products Corp., Wayne Junction, Philadelphia 44, Pa. Catalog No. 14-B, 32 pages. Numerous illustrations of both manual- and power-operated butterfly valves feature this presentation of a complete line of such valves, including detailed specifications, applications and descriptions of new types.

Cable and Wire Data—Cannon Electric Development Co., 3209 Humboldt St., Los Angeles, Calif. Loose-leaf booklet, 24 pages. Includes such data as standard telephone cable color code, interphone telephone cable, switchboard telephone cable, wire types used in telephone and signal installations, resistance of copper wire and carrying capacities of wires.

Electronics — Worner Electronic Devices, 848 N. Noble St., Chicago 22, Ill. Bulletin No. 9143, 4 pages. Covers operation of photoelectric devices for automatic control of production equipment, safety, lighting, combustion, sabotage and burglary.

Electrical Parts—Kolton Electric Mfg. Co., 123 New Jersey Railroad Ave., Newark 5, N. J. Bulletin L3, 8 pages. Describes and illustrates such electrical parts as bus straps, wire terminals and lugs, as specified by the U. S. Navy and Army Air Forces, and contract stampings.

Clutch—Carlyle Johnson Machine Co., 52 Main St., Manchester, Conn. Bulletin, 4 pages. Shows and explains construction and gives ratings and dimensions of the Maxitorq floating-disk clutch.

Welding—Eutectic Welding Alloys Co., 40 Worth St., New York 13, N. Y. Data book, 36 pages. Contains latest information on low-temperature welding.

Crystals—Brush Development Co., 3311 Perkins Ave., Cleveland 14, Ohio. Bulletin, 8 pages. Describes and illustrates several instruments, made by the company, that incorporate the Piezo electric crystal.

Fasteners—Shakeproof, Inc., 2501 N. Keeler Ave., Chicago, Ill. Brochure, 26 pages. Interesting and detailed presentation of how Shakeproof fasteners are used in military equipment. Numerous sketches are included.

Glass— Owens-Corning Fiberglas Corp., Toledo, Ohio. Booklet, 16 pages. Tells of the development, properties, manufacture and uses of Fiberglas.

Control—General Electric Co., Schenectady, N. Y. Booklet GET-1170, 48 pages. Consists mostly of published articles by General Electric engineers on the fundamentals of electronic control for resistance welding, but includes also a pictorial presentation of resistance-welding electronic controls and related equipment.

New Books

Sweet's File For Product Designers

Published by Sweet's Catalog Service, 119 W. 40th St., New York, N. Y. 1,540 pages, 8½x11 in., orange clothboard covers. Free to design executives.

Essential information on the products and services of 195 companies are given in the catalogs of this collection. This is the first issue of a file inaugurated to serve the specialized needs of men who select and specify materials, finishes and component parts for the products of their companies. Sections cover materials, finishes, parts, techniques and work equipment. The information presented in the individual catalogs is, generally, complete and arranged in such a manner as to be easily used for reference purposes.

S. P. I. Directory

Published by Society of the Plastics Industry, 295 Madison Ave., New York, N. Y. 160 pages, 6x9 in., red clothboard covers. Price $2.50.

All of the company and individual members of the society in the United States and Canada are listed in this first directory of the organization. As a source of suppliers of plastic products it should prove helpful to engineers. Company members in the United States and Canada are listed separately and the principal products of each company are given. There is also a product index for each country, with principal suppliers of each product given.

Physics of Metals

FREDERICK SEITZ. *330 pages, 5½x8 in., black clothboard covers. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y. Price $4.*

A fundamental and nonmathematical treatment of metals from the point of view of an atomic physicist, "Physics of Metals" is based on a lecture course presented for four years to metallurgists with a limited knowledge of physics and to physicists with a limited knowledge of metallurgy. It is one of a series on metallurgy and metallurgical engineering sponsored by Metals Research Laboratory of Carnegie Institute of Technology. The author heads the C.I.T. physics department. All of the tools and basic concepts of modern physics are applied to the study of metal structure, including factors determining the stability of alloys, elastic and plastic properties, creep, rupture and fatigue, theory of iron-carbon alloys, the electron theory of solids and its applications to cohesion, magnetism and conductivity. The material is well arranged and the book is interesting and thought provoking.

Kinematics And Machine Design

L. J. BRADFORD AND G. L. GUILLET. *357 pages, 5¼x7¾ in., green clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. Price $3.*

With the objective of making available a text which meets the requirements of short courses that combine kinematics and machine design, the authors have set forth methods for proportioning ordinary machine elements such as bearings, friction clutches and brakes, shafts and couplings, screw fastenings, gears and gear trains, belts, chains, springs, flywheels, flat plates and cylinders. The section on kinematics deals with the fundamental concepts of motion and velocity, then applies these considerations to the basic mechanisms. Numerous problems are included to give the student practice in applying the rules and formulas developed in the text.

Aircraft Descriptive Geometry

WALTER VAUGHN. *200 pages, 5¾x 8⅞ in., blue clothboard covers. Published by Aircraft Publishing Co., Glendale, Calif. Price $3.50.*

Second edition of this work, the present volume has been revised and enlarged to reflect the rapid advance and progressively higher standards of the aircraft industry. All of the illustrations have been redrawn or revised and many new illustrations and photographs added. Fundamentals of descriptive geometry are explained by what is known as the "direct" method of approach.

Army and Navy Specifications

Published by Headquarters, Air Service Command, Maintenance Division, Maintenance Data Section, Patterson Field, Fairfield, Ohio. 148 pages, 12x8⅝ in., gray cardboard covers. Free.

Purpose of this book is to present graphically information that will be helpful to government contractors in the preparation of manuscript and art for technical handbooks intended for publication by the Maintenance Data Section, Air Service Command. The material in the book was originally prepared for use in a slide film, but additional clarification is presented here in text on the pages facing the illustrations. Wherever possible examples of both good and poor styles of preparation of material are given. The book is unusually complete and thorough. It belongs in the file of every company that prepares illustrations of any kind for publication, whether or not such publication is to be undertaken by the Air Service Command.

Bulletins

Post-War Employment And the Settlement Of Terminated War Contracts

Published by Committee for Economic Development, 285 Madison Ave., New York, N. Y. 16 pages, 6x9 in.

After thoroughly investigating the settlement of terminated war contracts, including experience gained after World War I, the Research Committee of C.E.D. in this pamphlet recommends a four-point program for consideration by Congress to forestall the emergency that will arise when wholesale cancellation of contracts begins after the present war ends. These recommendations are: Creation by Congress of a contract settlement board, decentralize administration of contract settlement procedure, prompt recourse to courts in case of dispute, and mandatory loans to contractors and sub-contractors.

American Standards

Published by American Standards Association, 29 W. 39th St., New York 18, N. Y. 24 pages, 9¹¹⁄₁₆x10⅝ in. Free.

More than 600 standards are listed and the price of each is given in this latest edition of the A.S.A. list. Of the standards given, 64 have been approved or revised since publication of the previous edition in April, 1943. American War Standards and American Safety Standards are listed separately. In addition, there is a separate alphabetic listing of all the standards. This list represents the cumulative work of the past 25 years in practically every engineering and industrial field.

Volute Spring Design Data

H. O. FUCHS
General Motors Corporation

VOLUTE SPRINGS, roughly described as conical helical springs, are sometimes made of round wire, but more often of rectangular blades as shown in Fig. 1, with the coils nesting in each other so that the solid height of the spring equals the height or width of the blade.

Volute springs are used mainly for three reasons:

1. Load-deflection curve is not a straight line. The curve rises more and more steeply as deflections increase beyond the "transition point" where the largest coil first bottoms.

2. Springs are compact. When they are compressed solid, practically all the available space is taken up by resilient material.

3. High negative stresses can be trapped. Springs can be pushed "inside out" into a bowl to obtain a permanent set so that in operation the stresses will stay below the yield point, although the operating stress range may exceed the yield stress by 50 percent.

Drawbacks which in part offset these advantages are difficulties of manufacturing (it requires special machinery and specialized experience), a tendency to tilt during deflection, and somewhat tedious calculations. The curves presented help to overcome this last mentioned obstacle.

The type curves, Figs. 2, 3 and 4, are non-dimensional load-deflection diagrams having scales in terms of the total deflection h and of the load M at half total deflection. Total deflection h depends upon the number of coils, their radii, and their helix angles. Total deflection h can be calculated from Equation (1) which contains the auxiliary factor F to be taken from Fig. 5. Load M depends upon the foregoing factors and also upon the cross-section of the blade or wire and upon the modulus of rigidity of the material. Load M can be calculated from Equation (2), which contains the auxiliary factor Q to be taken from Fig. 6.

The highest operating stress range, from free to solid, which occurs on the smallest coil, is given by Equation (3). This is usually called "solid stress."

The degree to which the type curves deviate from a straight line depends upon only two factors; the ratio q of the smallest to the largest active coil radius and the ratio z of helix angle variation to coil radius variation.

The smaller q and z are, the more the load curve rises before the spring goes solid. This increase of load rate is to some extent purchased at the price of uneven stress distribution between the coils. For z equal to 1, Fig. 4, the bottoming stresses are uniform in all the coils. For z equal to 0, Fig. 2, the free helix angles are constant and the bottoming stresses increase in inverse proportion to the coil radii; for this case, springs with a ratio q of less than 0.5 are likely to be uneconomical since they imply that the stress range in the smallest coil is more than double the stress range in the largest coil. Fig. 3 shows an intermediate case.

In calculating a volute spring the total deflection h, load M at half deflection, permissible stress range S, and largest active coil radius R_l are usually dictated by the application or can be assumed. The first step is then the choice of q and z, with proper regard for the desired rise of load rate and permissible inequalities in stress range. Auxiliary factors F and Q are read off from Figs. 5 and 6. The cross-section of blade and the smallest helix angle a_s must then be found. This can be done conveniently by solving Equation (1) for $a_s n$, dividing Equation (2) by Equation (3) and solving for bt^2, and solving Equation (3) for $a_s t$.

Three equations are thus obtained for the four unknown quantities a_s, b, t, and n, indicating that there are many possible solutions. (This applies only to rectangular sections; for circular and square wire there is, of course, one unknown less). Solutions are obtained most easily by assuming values for t. The value of a_s is then determined by Equation (3), b by the equation for bt^2, and n by Equation (1). A check must be made to see if n coils of thickness t fit into the given space between the radii R_l and R_s, or qR_l. There should be enough gap left between the coils so that quenching oil can reach all

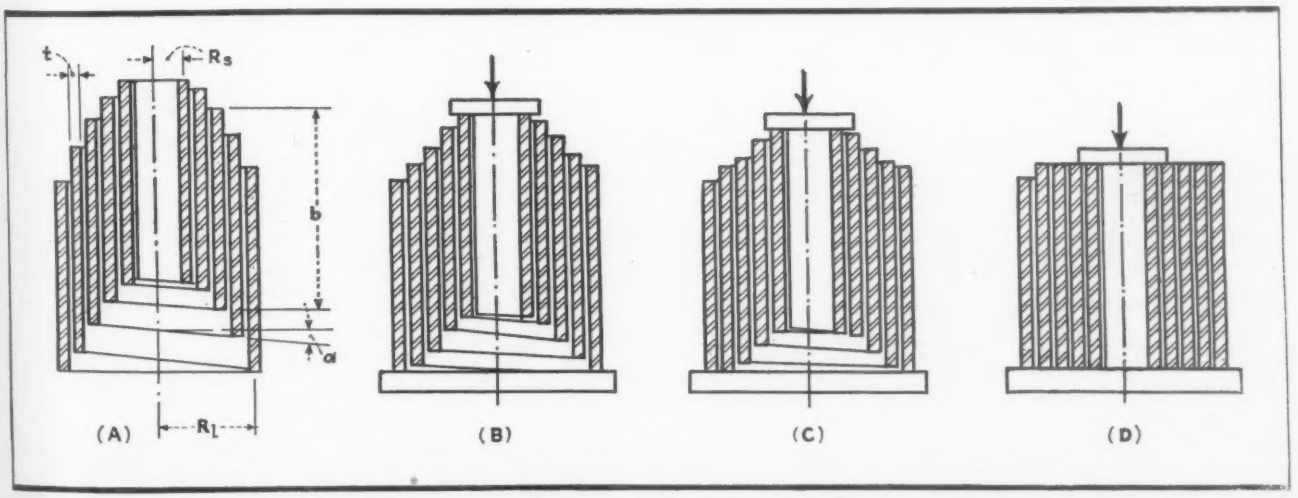


Fig. 1—Axial sections of a volute spring. (A) In unloaded or free position. (B) partially deflected, no coil bottomed. (C) First coil beginning to bottom. (D) In fully deflected or solid position.

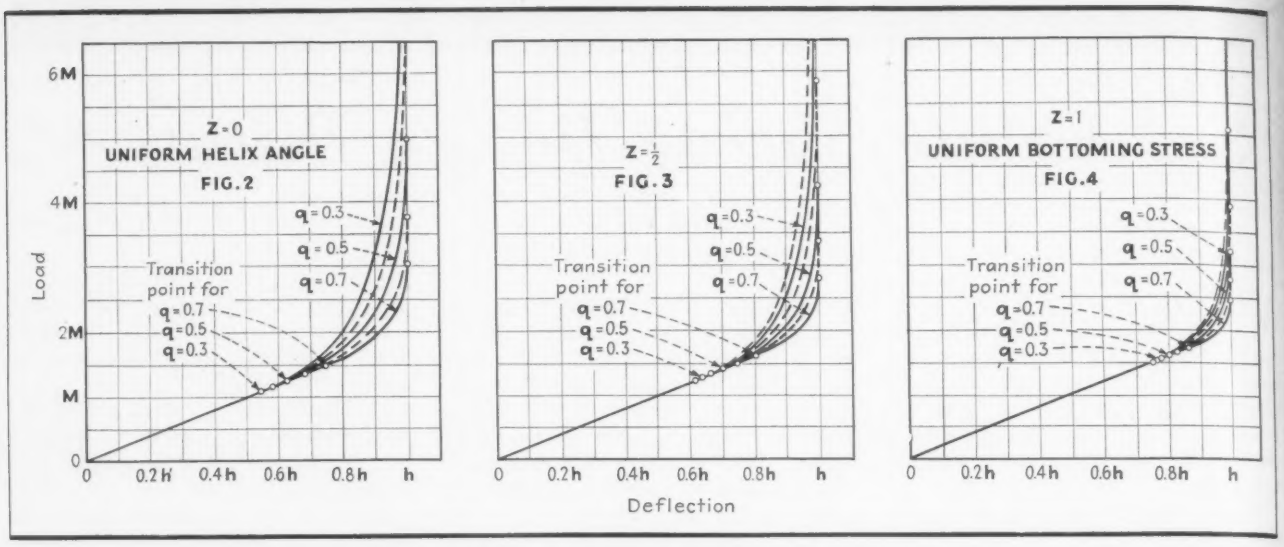


Fig. 2—Type curve for load and deflection if free helix angle is uniform. Fig. 3—Type curve for load and deflection if ratio of free helix angle variation to coil radius variation equals one half. Fig. 4—Type curve for load and deflection if ratio of free helix angle variation to coil radius variation equals one.

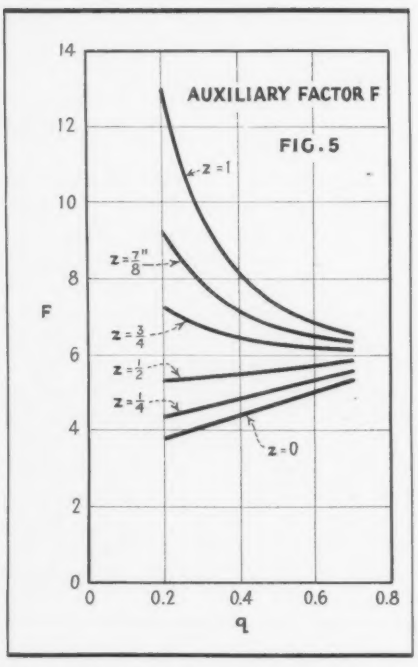


Fig. 5—Auxiliary factor F to be used in equations for load and for deflection.

of the coils, if the spring is to be heat-treated after coiling. Note also that the outside diameter of the spring must be larger than $2R_l$ to allow for the "dead" end coil.

Sample calculations are shown in the *SAE Journal*, Vol. 51, No. 9, pages 317 to 328, Sept. 1943, where the design of the setting-down bowl is also discussed and more curves, derivations, references, and acknowledgments are given.

Basis for Type Curves

The following symbols and equations are used

$$h = nR_l a_s F \quad (1)$$

$$M = Gbt^3 \frac{a_s}{R_l^2} \cdot QF \quad (2)$$

$$S = G \frac{a_s t}{qR_l} \quad (3)$$

G = torsional modulus of rigidity, approx. 11×10^6 lb. per sq. in. for steel
h = total deflection; free height minus solid height
M = load at ½ of total deflection
S = maximum stress range, usually called "stress"
n = number of active coils[1]
R_l = largest active free coil radius
R_s = smallest active free coil radius
a_s = helix angle at smallest active free coil radius
a_l = helix angle at largest active free coil radius
b = height (or width) of rectangular section blade
t = thickness of rectangular section blade
$q = R_s/R_l$ = ratio of smallest to largest active free coil radius
$z = \frac{1-(a_s/a_l)}{1-(R_s/R_l)}$ = ratio of helix angle variation to coil radius variation
F = auxiliary factor, plotted as function of q and z in Fig. 5
Q = auxiliary factor, plotted as function of q in Fig. 6

The curves are based on the following assumptions regarding the springs:

a. Uniform cross-section of the wire or blade.

b. Uniform radial pitch.

c. Uniform or uniformly varying free helix angles.

d. Load eccentricity and flexibility of "dead" end coils are neglected.

e. Coils bottom on a flat surface, not on each other or on a curved surface. Modifications to take care of deviating conditions are obvious.

f. Equations (2) and (3) for load and stress are for narrow rectangular blades; their torsional stiffness factor is approximated by $bt^3/3.14$. For other sections these equations must be multiplied by the ratios of torsional stiffness and stress factors. For square wire the load equation must be multiplied by 0.44, the stress formula by 0.67. For round wire the load equation must be multiplied by 0.31, the stress formula by 0.50 if b and t are replaced by the diameter.

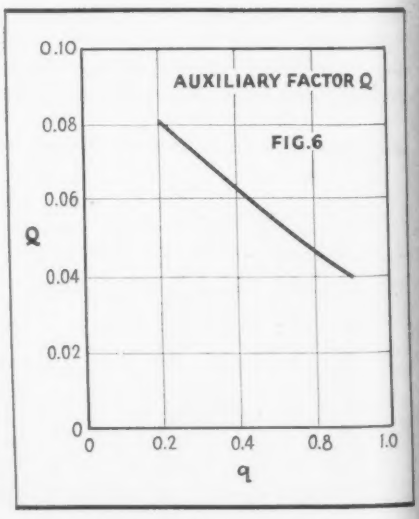


Fig. 6—Auxiliary factor Q to be used in equation for load.